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INTEGRATED SIMULATION EVALUATION MODEL PROTOTYPE (ISEM-P) OF THE AIR FORCE MANPOWER AND PERSONNEL SYSTEM: OVERVIEW AND SENSITIVITY ANALYSIS

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The Integrated Simulation Evaluation Model Prototype (ISEM-P) is a computer program that simulates the basic planning activities and decision-making procedures involved in the Air Force Manpower and Personnel System (AFMPS). It embodies a dynamic modular representation of the AFMPS in which aggregate manpower planning, training program management, detailed personnel assignment scheduling, and actual personnel flows are characterized as integrated, interdependent activities that control the evolution of the force over time. ISEM-P has been designed as a prototype for a large-scale model that would serve as an analytical tool in predicting and evaluating the impacts of changes in policies, procedures, and environmental conditions on the performance of the entire AFMPS. This technical report presents a detailed overview of ISEM-P and summarizes the results of an extensive

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sensitivity analysis of the prototype. Included in the report are a brief discussion of the organization, functions, and operation of the AFMPS; a more detailed explanation of the structure and operation of ISEM-P, and its relationship to the AFMPS; a discussion of the conceptual framework and analytic methodology employed in the sensitivity analysis; a summary of the results derived by applying the methodology to assess the sensitivity of ISEM-P within the context of the conceptual framework; and a listing of the conclusions and recommendations emerging from the analysis.

Preface

This report documents the development of the Integrated Simulation Evaluation Model Prototype (ISEM-P). This research program began in 1974 as a project to determine the feasibility of building a descriptive model of the Air Force Manpower and Personnel System (AFMPS). The project has seen the initiation of a spin-off, stand-alone effort in the area of estimating parameters and modeling the relationships between the AFMPS and the national labor market. The primary product has been the development of a large-scale simulation model of the AFMPS which describes and analyzes the information flows and decision dynamics of the various subsystems comprising the total AFMPS. The model incorporates state-of-the-art simulation techniques using the SIMSCRIPT II.5 simulation language and, although on a reduced scale, does provide a reasonable representation of the AFMPS. Much of this work has been completed under Project 2077, Task 02, and the labor market research is being conducted presently under Project 7719, Task 20. This entire research effort is encompassed under the Force Acquisition and Distribution Thrust and specifically the Acquisition, Classification and Assignment Subthrust.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The Integrated Simulation Evaluation Model Prototype (ISEM-P) is a computer program, written in the SIMSCRIPT II.5 language, which simulates the basic planning activities and decision-making procedures involved in the Air Force Manpower and Personnel System (AFMPS). It embodies a dynamic modular representation of the AFMPS in which aggregate manpower planning, training program management, detailed personnel assignment scheduling, and actual personnel flows are characterized as integrated, interdependent activities that determine the status of groups of personnel and thereby control the evolution of the force structure over time.

ISEM-P has been designed as a prototype for a large-scale model -- the Integrated Simulation Evaluation Model (ISEM) -- that would serve as an analytic tool in AFMPS planning and policy formulation. In particular, ISEM would be useful for predicting and evaluating the impacts of changes in policies, procedures, and environmental conditions on the performance of the entire AFMPS. One of the primary goals in developing ISEM-P has been to create an operational computer program that would demonstrate the technical feasibility of the ISEM concept and suggest the potential usefulness of a larger, more comprehensive version of the model.

Achieving this state of model development has involved performing three evolutionary research activities:

1. Design of a practical methodology for simulating the behavior of the AFMPS, resulting in establishment of the basic structure of ISEM.

2. Programming and implementation of an initial version of the model on the UNIVAC 1108 computer at the Air Force Human Resources Laboratory (AFHRL).

3. Evaluation, testing, augmentation, and improvement of the initial formulation to arrive at the current configuration of ISEM-P.

Having accomplished these tasks, it is now appropriate to examine the robustness of the representation of the AFMPS contained in the prototype. Consequently, this report summarizes the results of an extensive sensitivity analysis of ISEM-P: an in-depth analysis of the changes in simulated performance that result from systematic adjustments of the values of program parameters associated with key issues concerning the structure of the prototype.

To provide an adequate understanding of the activities simulated in ISEM-P, a brief description of the organization, functions, and operation of the AFMPS is presented in Section 2.0. Then, to establish a suitable perspective for interpreting the sensitivity analysis and its implications, Section 3.0 contains a more detailed explanation of the ISEM concept, the structure and operation of ISEM-P, and the resultant relationship between the prototype and the concept.

The conceptual framework and analytic methodology exployed in the sensitivity analysis are discussed in the next two sections. The results derived by applying the methodology to assess the sensitivity of the prototype's performance within the context of the conceptual framework are then summarized in Section 6.0. The conclusions and recommendations emerging from the results of the sensitivity analysis are reported in the final section.

2.0 OVERVIEW OF THE AIR FORCE MANPOWER AND PERSONNEL SYSTEM

To appreciate the logic underlying the structure and operation of ISEM-P, it is first necessary to obtain a basic understanding of the AFMPS: its goals and responsibilities, its operating environment, the constraints on its actions, and its organizational structure. A simplified representation of the AFMPS and the environment in which it functions is presented in Figure 1.

The AFMPS is responsible for the procurement, development, maintenance, and deployment of the human resources available to the Air Force. Thus, it exercises substantial control over the fundamental characteristics of occupational life in the Air Force: where people are stationed, what jobs they perform, and what training they receive. The AFMPS also exerts considerable influence over entry into and exit from the service through the actions it takes at the control points associated with airman and officer procurement and retention. Most importantly, it provides the essential link between people and jobs that enables the Air Force to accomplish the objectives established in the Five-Year Defense Plan (FYDP).

Essentially, the goals and objectives driving the AFMPS consist of providing people

1. Of the right kind
2. At the right place
3. At the right time
4. In sufficient quantity
5. To staff the mission functions
    - Required to support budgeted Air Force programs
    - According to established manpower standards
6. At lowest cost

The ability of the AFMPS to achieve these goals and objectives is limited, however, by three basic sets of organizational and environmental constraints:

1. Authorization ceilings
2. Policy directives
3. Exogenous labor market forces

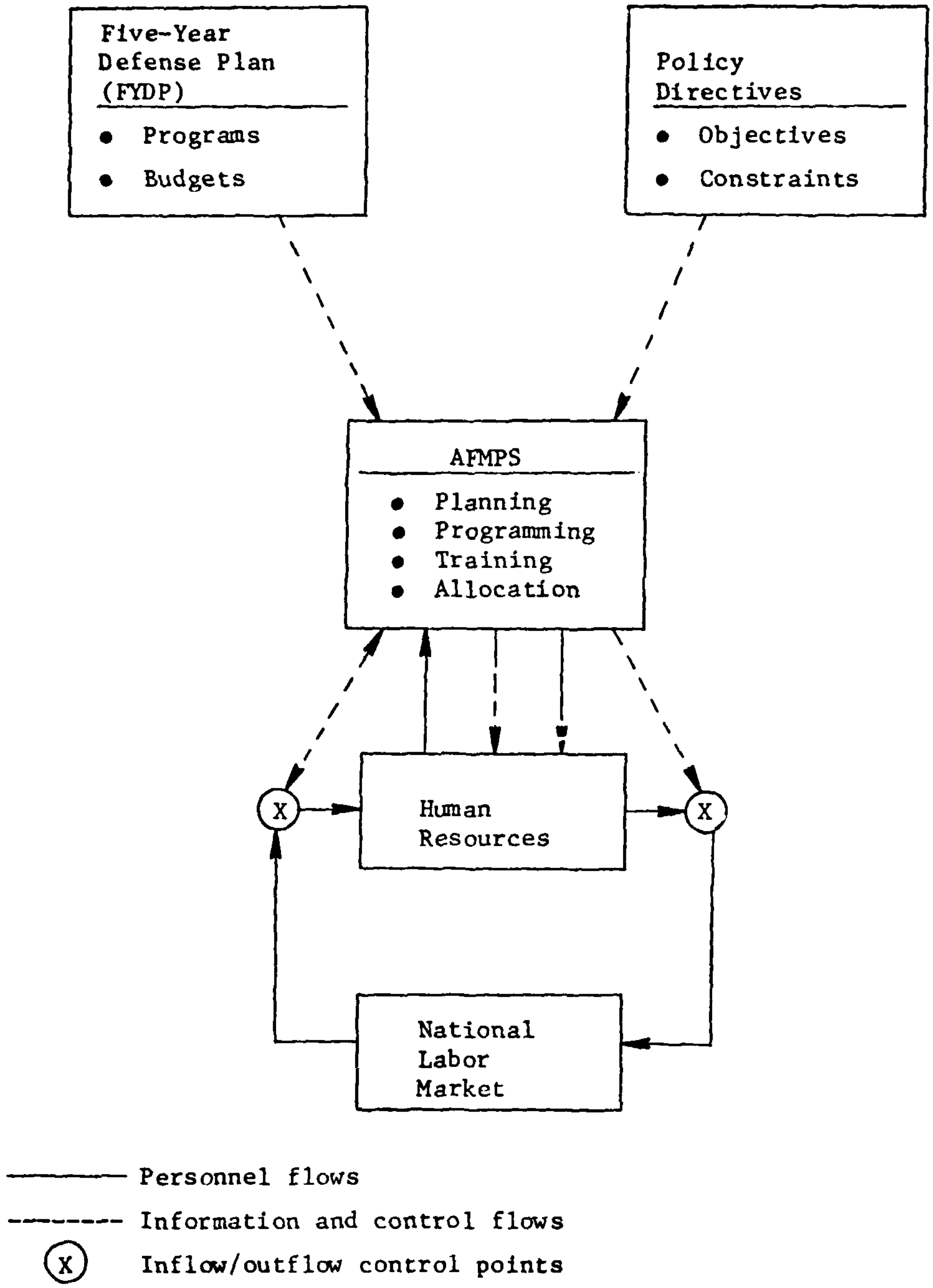


Figure 1. The AFMPS environment.

Budgeted programs basically correspond to various missions the Air Force is charged with performing, such as weapons systems operations. The missions are assigned to particular bases, or other installations; and require the performance of a number of specific, sometimes highly technical, jobs. For the Air Force to accomplish these missions, the right amounts of personnel, possessing an appropriate mix of skills and experience, must be available at the bases.

Assuring continued personnel availability is an inherently dynamic process. Supplying the desired people entails providing the necessary training and transportation. Further, the characteristics of the available personnel change over time as, for example, some people become more experienced, some change career ladders, and some leave the force. The demand for personnel also changes as, for instance, the FYDP is modified or mission manpower requirements are revised. In response to such changes, the system must adjust the stock in a timely fashion to remain in equilibrium. Moreover, as in any economically-constrained situation, the system must strive to limit the costs incurred in its operation.

To achieve these goals, the AFMPS organization is operationally partitioned into three distinguishable components: manpower, personnel, and training. Organizationally, the manpower and personnel components are both administered by the Manpower and Personnel Command (MPC); while training is the responsibility of the Air Training Command (ATC). Functionally, however, all three components can realistically be regarded as independent entities.

The manpower component is responsible for determining the needs for skilled personnel in various occupational specialties, at various levels of expertise and authority. These effective demands for personnel are derived from established plans to staff particular Air Force mission elements at specific geographic locations, based on known mission technologies, labor productivities, and defense plan budgets.

The personnel component is responsible for maintaining adequate supplies of personnel who have suitable skills and experience who are appropriately located geographically to satisfy the needs defined by the manpower component. Moreover, the demands for personnel must be filled on a time schedule that ensures continuing combat readiness and guarantees the availability of sufficient personnel to meet anticipated future needs through established career progression sequences.

The training component is responsible for recruiting and developing new personnel to replenish or augment existing supplies and for furnishing the education that enables current personnel to acquire new skills and become more proficient at old ones. Through these activities, a dynamic mechanism is provided for reconciling skilled personnel supplies and demands over time.

Through the years, each component has developed objectives, performance measures, methods, and procedures that are well suited to its perception of its own responsibilities. Consequently, it is difficult for any single Air Force organization to have comprehensive understanding and control of the operation of the AFMPS.

Yet, obviously, the three components of the AFMPS are interrelated, and their performance can be highly interdependent. For example, modification of the procedures employed by any one of the components can have substantial effects on the ability of the other components to fulfill their responsibilities. Thus, it seems desirable to develop a capability to anticipate and adjust appropriately for the system-wide implications of changes in policies, procedures, and environmental conditions affecting the AFMPS. This is the precise reason why ISEM has been designed as a planning and policy formulation tool, and ISEM-P has been developed as an exploratory device.

3.0 THE STRUCTURE OF ISEM AND ISEM-P

The central concept underlying ISEM is that the manpower, personnel, and training components of the AFMPS can be viewed as parts of a large information-feedback control system. From this perspective, a simulation model could be developed that would depict the impact of one component on the others -- and on the system as a whole -- in terms of the changes that occur in personnel supplies and the responses that these changes stimulate. Ultimately, as illustrated in Figure 2, ISEM would consist of five elements:

1. A Policy/Information/Control (PIC) Module, representing the data gathering, information processing, and decision-making aspects of the AFMPS.

2. A Personnel Force Structure Module, representing the stock of Air Force personnel, aggregated into as many categories as are relevant to the PIC decision processes.

3. Training and Transportation Pipelines, representing the flows of personnel from one category to another, and the processes that implement these flows.

4. A National Labor Market Module, representing the changing mix of sources and sinks for personnel in the world outside the Air Force.

5. Evaluation Systems, comprising a collection of measurement and report generation procedures displaying the performance of the AFMPS and each of its components over time.

The principal use intended for ISEM would then be to predict the system-wise implications of changes in PIC policies and procedures and in national labor market conditions, for use in AFMPS planning and policy development efforts.

In contrast, the purpose of ISEM-P has been to develop a working prototype of the ISEM concept. As a prototype, the design of ISEM-P corresponds closely to the structure formulated for the full ISEM. However, to allow an operational system to be developed relatively soon and inexpensively, the elements of the model have been somewhat scaled-down and simplified in the prototype. In fact, two elements -- the National Labor Market Module and the Evaluation Systems -- have been omitted entirely. The resultant relationship between ISEM-P and ISEM is shown in Figure 2.

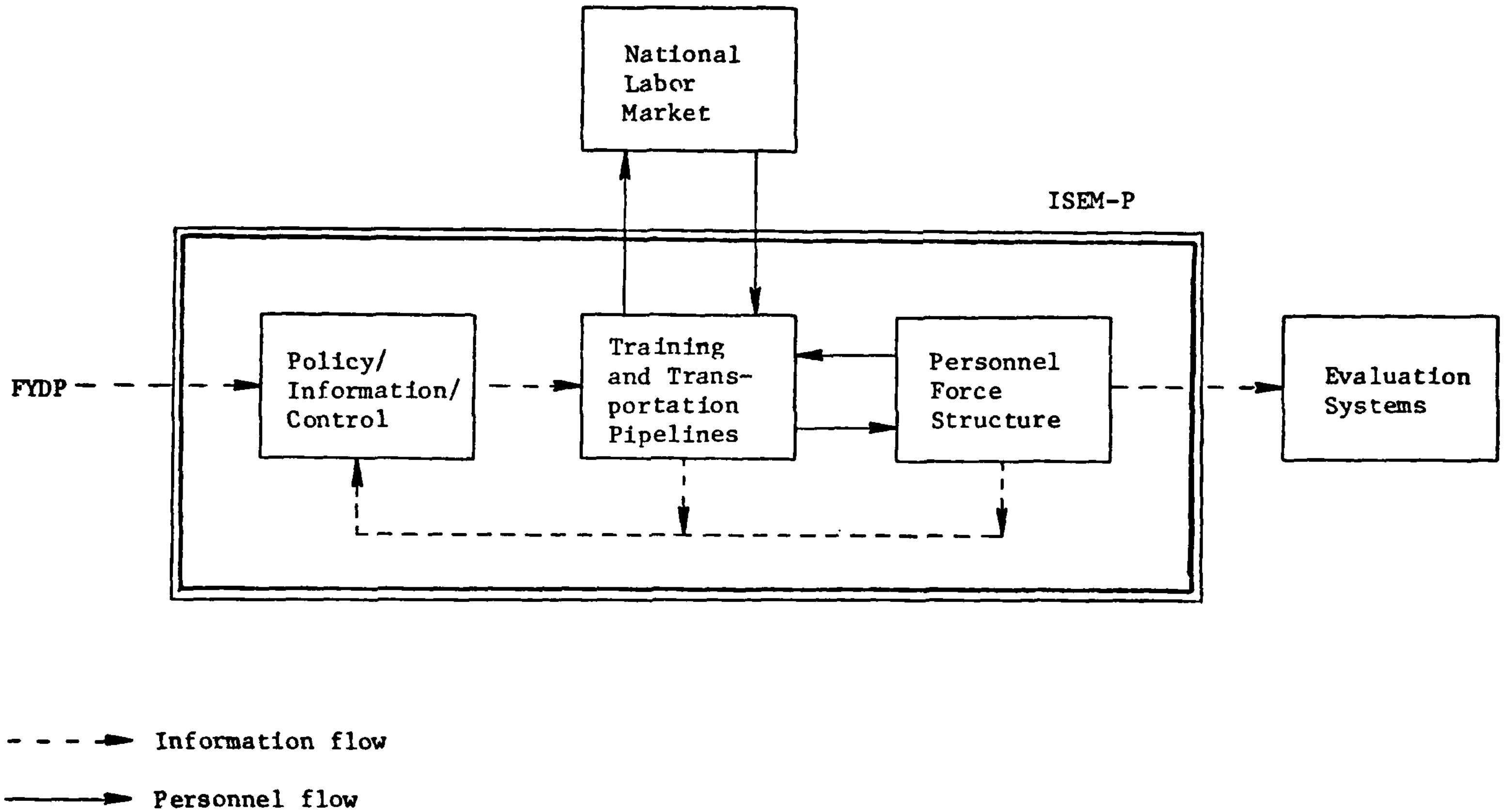


Figure 2. ISEM and ISEM-P elements.

3.1 ISEM-P Personnel Force Representation

The most important element in any personnel planning model is the representation chosen for the stock of personnel. This representation establishes the level of detail contained in the model and, hence, almost completely determines the amount of input data required, the kinds of decisions susceptible to simulation, and the types of questions amenable to analysis. ISEM-P, like ISEM, is an aggregate model; i.e., it deals with groups of personnel rather than individuals. Every personnel group is characterized by one or more of five properties: skill, grade, year group, base, and time-on-station.

Skill is designated by a code indicating the type of job a group of personnel is capable of performing. ISEM-P skill codes correspond fundamentally to Air Force Specialty Codes (AFSCs) used by the AFMPS to categorize occupational expertise. However, only those skills required by the missions represented in ISEM-P have been included in the prototype. Moreover, most ISEM-P skill codes constitute a merger of several AFSCs: some at the general career field level corresponding to two-digit AFSCs, others at the career group level associated with three-digit AFSCs, and the remainder at more detailed specialty levels. Skill level, the degree of proficiency designated by the fourth digit of an airman AFSC, is not explicitly represented in the prototype. However, skill level is strongly correlated with grade. Altogether, there are 51 airman skill codes and 40 officer skill codes included in ISEM-P. The code, AFSC, and title of each skill contained in the prototype is listed in Table 1.

Within each skill, personnel are stratified by grade, or rank. As with the skill codes, an ISEM-P grade usually represents more than one actual Air Force grade. The correspondence is:

ISEM-P Grade	Airman Grades	Officer Grades
1	E1 and E2	2nd Lieutenant
3	E3	Lieutenant
5	E4 and E5	Captain
7	E6 and E7	Major
9	E8 and E9	Lt Colonel and Colonel

Civilian personnel management is not simulated in the prototype. Hence, there are no civilian grades in ISEM-P.

A year group specifies the number of years a group has served in the Air Force, and is essentially analogous to the AFMPS measure of Total Active Federal Military Service (TAFMS). Thirty year groups are delineated in the prototype.

Table 1: ISEM-P Skill Codes

Airman			Officer		
Skill	AFSC	Function	Skill	AFSC	Function
1	111X0	Aerial gunner	52	1045L	C-141 pilot
2	112X0	Refuel operator	53	1055B	C-130 pilot
3	114X0	Loadmaster	54	1065C	KC-135 pilot
4	20XXX	Intelligence	55	1115F	F-4 pilot
5	22XXX	Photomapping	56	1115G	F-111 pilot
6	25XXX	Weather	57	1235C	B-52 pilot
7	271X0	Air operations	58	1325F	RF-4 pilot
8	272X0	Air traffic controller	59	1525A	B-52 navigator
9	276XX	Detection and deployment	60	1535G	KC-135 navigator
10	291X0	Telecommunications operator	61	1545G	C-130 navigator
11	293X3	Radio operator	62	1545L	C-141 navigator
12	302XX	Weather equipment repair	63	1555B	F-4 navigator
13	303XX	Radar equipment repair	64	1555C	RF-4 navigator
14	304XX	Radio equipment repair	65	1555E	F-111 navigator
15	305XX	Computer systems repair	66	1575C	B-52 electronic weapons officer
16	306XX	Communications and cryptography repair	67	16XX	Air traffic controller
17	321X0	Bomb and navigation systems mechanic	68	17XX	Weapons control
18	321X1	FCS mechanic	69	25XX	Weather
19	322XX	Weapons control systems mechanic	70	30XX	Communications-electronic systems
20	325XX	Flight control and instrument mechanic	71	306X	Computer maintenance
21	326XX	Integrated avionics mechanic	72	40XX	Aircraft avionics maintenance
22	328XX	Avionics-guidance mechanic	73	46XX	Munitions
23	341X1	Instrument trainer	74	51XX	Computer technology
24	341X2	Defensive systems trainer	75	55XX	Civil engineering
25	342XY	Navigation, bombing and tactics trainer, Y = 4, 5, 7	76	60XX	Chartography
26	36XXX	Wire communications systems maintenance	77	62XX	Transportation
27	42XXX	Aircraft accessory repair	78	63XX	Supply
28	426X0	Propeller aircraft maintenance	79	65XX	Fuels
29	431X1	Jet aircraft maintenance	80	66XX	Procurement
30	426X2	Jet engine mechanic	81	67XX	Finance
31	426X1	Propeller engine mechanic	82	70XX	Administration
32	461X0	Munitions maintenance	83	7YXX	Personnel-manpower, Y = 3, 4
33	462X0	Weapons mechanic	84	75XX	Education-training
34	47XXX	Vehicle maintenance	85	80XX	Intelligence
35	51XXX	Computer systems operator	86	81XX	Security police
36	427XX	Metalworking	87	9YXX	Biomedical, Y = 1, 2
37	54XXX	Mechanical and electrical maintenance	88	92XX	Physician, Z = 3, 4, 5
38	55XXX	Civil engineer	89	97XX	Nurse
39	57XXX	Fire protection	90	98XX	Dentist
40	60XXX	Transportation	91	99XX	Veterinarian
41	62XXX	Food service			
42	63XXX	Fuel service			
43	64XXX	Supply			
44	65XXX	Procurement			
45	67XXX	Accounting and finance			
46	70XXX	Administration			
47	73XXX	Manpower-personnel			
48	75XXX	Training support			
49	81XXX	Security police			
50	90XXX	Medical-dental			
51	92XXX	Aircrew protection			

Each base in ISEM-P represents an actual Air Force base. It possesses all pertinent geographic, organizational, and tour-length characteristics of its real counterpart. The missions assigned to the simulated bases correspond to the missions attached to the analogous real bases, and the groups of personnel associated with the bases in the prototype conform to the personnel actually assigned to the applicable mission functions at the real bases. While the full ISEM would embody all bases and other Air Force facilities, 17 bases have been selected as a reasonable set for inclusion in the prototype. Of these 17 bases, 13 are located in the Continental United States (CONUS), two in Europe, and two in the Pacific. Moreover, of the 13 CONUS bases, three are affiliated with ATC, three with the Military Airlift Command (MAC), three with the Strategic Air Command (SAC), and four with the Tactical Air Command (TAC). A complete list of the bases included in the model, their geographic locations, and their organizational affiliations is presented in Table 2.

Time-On-Station (TOS) is the number of months a person has resided at a base. This property is used by the AFMPS to determine when the person may be, or must be, moved to another base. Within ISEM-P, a TOS frequency distribution is dynamically maintained for each personnel group at each base.

The structure of the personnel force at any time is then represented in the prototype in terms of the composition of the stock of personnel relative to the preceding five properties: skill, grade, year group, base, and TOS. Thus, these are the basic dimensions within which the representations of Air Force decision rules contained in ISEM-P operate.

3.2 ISEM-P Decision Types

Of all the various kinds of decisions routinely made by the AFMPS, six basic types are represented in the PIC Module of the prototype:

1. Personnel authorization decisions determining the mix of personnel required to support budgeted missions, and reconciling these requirements with the number of personnel authorized in the FYDP.

2. Airman and officer procurement decisions evoking the flow of entrants into the force, and reflected in increases in the number of junior personnel in all skills at all bases.

3. Promotion decisions affecting the distribution of the force across grades.

Table 2: ISEM-P Bases

Base Number	Base Name: ISEM-P	Base Name: Actual	Location	MAJCOM[a]
1	Training 1	Lackland	San Antonio, Texas	ATC[b]
2	Training 2	Lowry	Denver, Colorado	ATC[b]
3	Training 3	Williams	Mesa, Arizona	ATC[b]
4	APOE[c] East	McGuire	Trenton, New Jersey	MAC[d]
5	APOE[c] West	Travis	Fairfield, California	MAC[d]
6	Operations 1	Homestead	Homestead, Florida	TAC[e]
7	Operations 2	Ellsworth	Rapid City, South Dakota	SAC[f]
8	Operations 3	Grand Forks	Grand Forks, North Dakota	SAC[f]
9	Operations 4	Loring	Limestone, Maine	SAC[f]
10	Operations 5	Pope	Fayetteville, North Carolina	MAC[d]
11	Operations 6	Shaw	Sumter, South Carolina	TAC[e]
12	Operations 7	Mountain Home	Boise, Idaho	TAC[e]
13	Operations 8	George	Victorville, California	TAC[e]
14	Overseas 1	Bitburg	Bitburg, West Germany	USAFE[g]
15	Overseas 2	Alconbury	Alconbury, United Kingdom	USAFE[g]
16	Overseas 3	Kadena	Kadena, Okinawa	PACAF[h]
17	Overseas 4	Kunsan	Kunsan, Korea	PACAF[h]

[a]Major Command
[b]Air Training Command
[c]Aerial Port of Embarkation
[d]Military Airlift Command
[e]Tactical Air Command
[f]Strategic Air Command
[g]United States Air Forces in Europe
[h]Pacific Air Forces

4. Training decisions providing for the distribution of personnel among skills.

5. Transfer decisions producing the distribution of the force over bases.

6. Separation decisions producing the flows of personnel out of the force, and hence reducing the number of people in various groups.

None of these decisions directly alters the distribution of the force across year groups: the force simply gets older each year. However, recruiting, promotion, training, and separation decisions all affect this distribution, or some disaggregation of the distribution, indirectly. Similarly, TOS is not directly controllable, although its distribution across bases can be manipulated through appropriate transfer decisions.

The first five types of decisions are organizational decisions expressly taken to promote the objectives of the AFMPS. Conversely, the last type, separation decisions, are principally actions taken by individual Air Force personnel to serve their own private interests. They are not directly determined by the AFMPS, and hence may or may not be compatible with AFMPS objectives.

The representations of decision rules included in ISEM-P are all essentially deterministic. Stochastic, or random, elements have been included in only a few simulated decision rules, and these elements merely establish default conditions to deal with situations that should never arise overtly in the prototype, but might evolve through some circuitous sequence of events.

3.3 ISEM-P Decision-Making Levels

Management decisions are made at numerous levels in the AFMPS, including the Air Staff, major command, and base levels. Each level operates on a different time scale, considers a different planning horizon, and uses a different aggregation of the force structure in its decision making.

Two levels of decision-making are represented in ISEM-P. They have been implemented as two distinct submodels: the aggregate submodel and the assignment submodel.

The aggregate submodel operates on a yearly cycle. It develops and actuates long-range force structure plans for a horizon period corresponding to the end of the current simulated year. In this planning process, the stock of personnel is described in terms of an array

called the inventory, whose three dimensions are skill, grade, and year group.

Within ISEM-P, the FYDP is represented as five yearly mission plans and five annual authorization ceilings. The mission plan summarize the programs included in the FYDP by stating which missions are to be attached to which bases during each simulated year. The authorization ceilings, conversely, express the budgetary restraints specified in the FYDP in terms of the authorized end-strengths for airmen and for officers in each simulated year. Authorized end-strength is the maximum total number of personnel allowed to be in the force performing mission functions at the end of a year.

Each simulated year, the aggregate submodel receives as inputs the mission plan and authorization ceilings for that year, and proceeds to perform five basic operations. In these operations, the submodel

1. Converts the mission plan into manpower requirements and, then, transforms the requirements into detailed authorizations.

2. Projects the expected state of the inventory after anticipated attrition.

3. Formulates promotion, training, and recruiting plans designed to change the state of the inventory to conform to the detailed authorizations.

4. Removes actual separation losses from the inventory.

5. Applies the formulated plans to the inventory.

This process produces the inventory that serves as a primary input to the next annual planning cycle. The formulated plans and actual results are also passed as inputs to the assignment submodel.

The assignment submodel operates on a monthly cycle. It develops and implements short-range plans for personnel flow among bases for a horizon period nominally 9 months ahead of the current simulated month. In this submodel, personnel groups, identified by skill and grade, are distributed among the bases to derive the stock of personnel at each base, termed the base supply. Each personnel group within each base supply is further stratified by the time-on-station in the manner described in Section 3.1.

More precisely, the assignment submodel converts the plans formulated for each simulated year in the aggregate submodel into month-by-month, base-by-base schedules for separations, promotions, and training assignments. It also schedules all transfers among bases necessitated by policies restricting the length of overseas tours,

and allocates newly trained personnel to bases. The schedules are established for the horizon period on the basis of projections of base supplies and base authorizations for that period. Then, the schedules are applied to the actual base supplies to simulate the resultant flows of personnel through training and among bases.

Unavoidably, the recruitment, separation, and, to some extent, training decisions simulated in the prototype must diverge from those that would be generated in the full ISEM, since the ultimate effects of such decisions would strongly depend on interactions with the National Labor Market Module. ISEM-P assumes that all airman and officer procurement demands will be fulfilled, in terms of both quantities and aptitudes. In an analogous manner, separations in ISEM-P are completely controlled by an exogenously supplied set of separation rates for each group in the inventory.

The basic operation of ISEM-P, focusing on its two submodels and their interrelationships, is displayed schematically in Figure 3. This figure reveals a basic difference between the information-feedback opportunities available within the inventory and the base supply planning processes. Because the inventory planning horizon corresponds exactly to the length of the inventory planning cycle, each inventory plan developed in the aggregate submodel is based on the actual state of the inventory realized at the end of the preceding cycle. In contrast, the base supply planning horizon is equal in length to nine base supply planning cycles. Consequently, each base supply plan formulated in the assignment submodel necessarily depends on the plans and projections developed for the eight intervening months between the current simulated month and the planning horizon. The resultant difference in information-feedback mechanisms is highlighted in Figure 3, where a single integrative feedback loop appears within the aggregate submodel, while two essentially independent loops are depicted for the base supply planning and base supply flows portions of the assignment submodel.

Taken together, the two component submodels of the prototype simulate the interaction of all of the AFMPS goals, objectives, and constraints discussed in Section 2.0. However, each submodel addresses a distinct subset of those concerns. Moreover, even where both submodels examine the same issue, the manner in which the issue is resolved frequently varies.

To enhance appreciation of these differences, more detailed descriptions of the two submodels are presented in the next two sections. The aggregate submodel is discussed in Section 3.4, and the assignment submodel in Section 3.5.

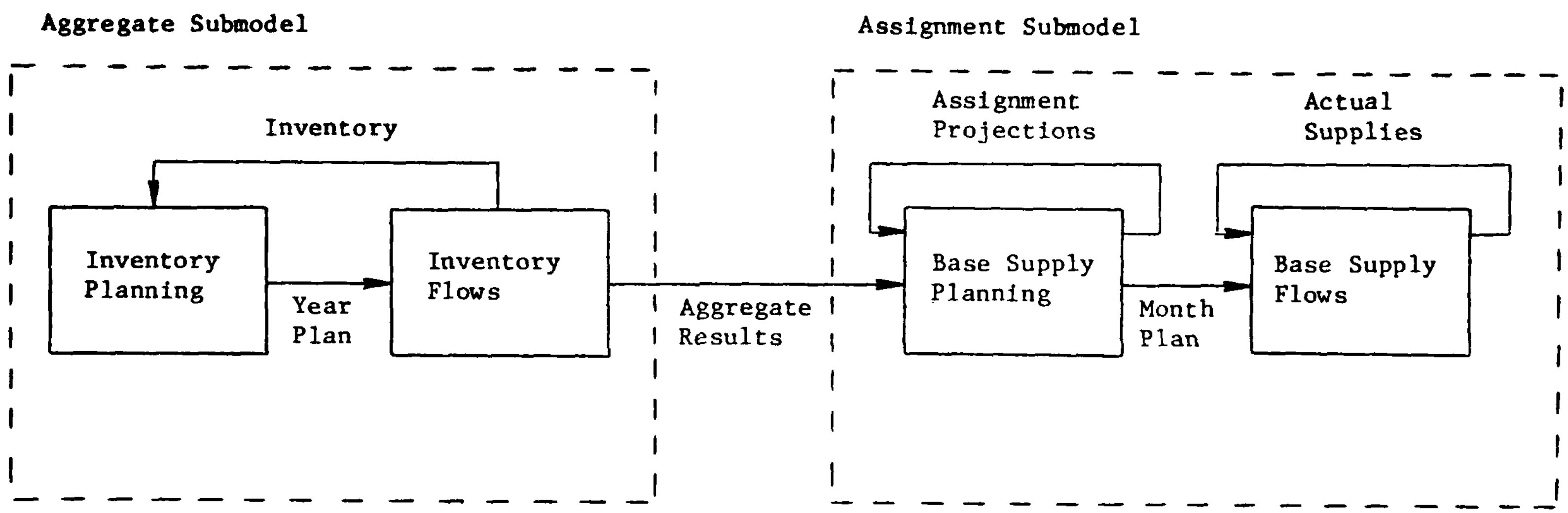


Figure 3. The ISEM-P system.

3.4 The Aggregate Submodel

As its name implies, the aggregate submodel simulates AFMPS force structure planning and adaptation at a relatively cumulative level. Essentially, this submodel does not consider the distribution of personnel among bases. Similarly, except to the extent that cost considerations are reflected in Air Force program budgets and established manpower standards, it is not concerned with controlling cost. Rather, the subset of AFMPS goals and objectives simulated in the aggregate submodel consist of providing people

1. Of the right kind

2. At the right time

3. In sufficient quantity

4. To staff the mission functions

    - Required to support budgeted Air Force programs
    - According to established manpower standards

As before, the feasibility of attaining the operative goals and objectives is constrained by

1. Authorization ceilings

2. Policy directives

3. Exogenous labor market forces

Moreover, as indicated previously, within the aggregate submodel the "right kind" of personnel are identified in terms of skill, grade, and year group; and the "right time" corresponds to the end of the current simulated year.

Three principal AFMPS policy directives are embodied in the submodel. When total manpower requirements exceed authorization ceilings, manpower policy establishes the priorities attached to different skills in determining detailed authorizations. Next, Air Force promotion policy stipulates, for each grade, the specific year groups from which promotions into the next higher grade may be drawn. Finally, the equal promotion opportunity policy requires that all airmen in any grade are eligible for promotion on the same terms regardless of the skill in which they have been trained. Representations of all three of these policies are incorporated into the simulated decision rules contained in the submodel.

As stated previously, the stock of personnel is characterized in the aggregate submodel as a three-dimensional array called the inventory. At the start of each submodel cycle, the inventory describes the population present at the beginning of a simulated year. Each cell in the array indicates the size of the group having the skill, grade, and year group properties that index the cell. A few cross-sections of the inventory array are illustrated in Figure 4. In this figure, grades are labeled by the codes 1, 3, 5, 7, and 9; skill codes range from 1 to 91, where 1 to 51 correspond to airmen categories and 52 to 91 comprise officer categories; and year group indices extend from 1 to 30.

Figure 4 also depicts the five possible types of flows into, out of, and within the inventory. Flows 1 and 5 constitute entry and exit respectively; while the remaining three flows -- promotion, aging, and cross-training -- occur along the three dimensions of the array. Entry-level trainees are accounted for separately, and do not appear in the inventory array until their initial skill is established.

The aggregate submodel operates in two phases: the planning phase and the flow phase. Thus, for each simulated year, a year plan is formulated based on the initial inventory and the mission plan for that year. Then, the year plan is executed on the inventory to produce the simulated personnel flows shown in Figure 4. The resultant array describes the inventory at the end of the current year, which, of course, corresponds to the initial inventory for the next submodel cycle.

The first activity performed in the planning phase in each simulated year involves determining, on the basis of the mission plan and authorization ceilings entered as inputs into the aggregate submodel for the year, the overall goals that the aggregate planning phase is to achieve with its year plan. These goals -- the detailed manpower authorizations -- indicate the number of personnel, partitioned by skill and grade, allowed to be in the inventory at the end of the year.

The first step in calculating the detailed authorizations consists of determining the aggregate manpower requirements: the amount of manpower in each skill and grade that could optimally be employed at mission tasks solely on the basis of workload and productivity considerations, regardless of the size of the budget. These requirements are derived by applying a set of manning standards to the mission specifications contained in the mission plan.

The mission specification for each base describes the outputs that must be produced at the base to support its mission. While the full ISEM would encompass all Air Force programs and missions, only two types of primary missions and two types of secondary missions are included in ISEM-P. The primary missions are flying and training, and the secondary missions are flying support and base support.

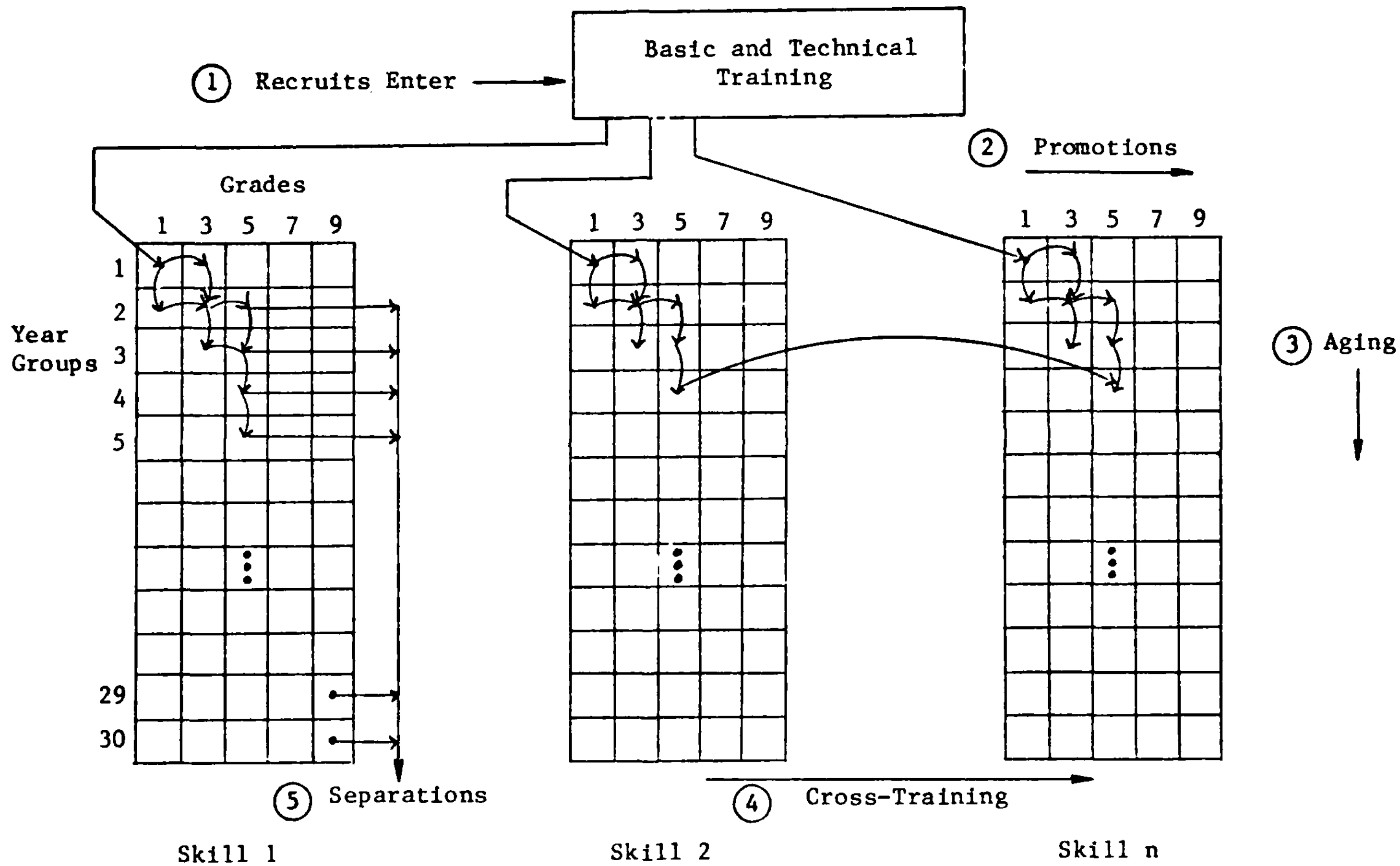


Figure 4. Aggregate submodel stocks and flows.

The output of a flying mission is defined to be some number of flying hours per month for a particular kind of aircraft. The output description designates the aircraft, the number of squadrons of that aircraft attached to the base, and the required flying hours per aircraft per month. Training mission outputs are defined in terms of students trained per month for a particular kind of student. The amount of output required depends on the flying mission requirements and the number of suitably skilled personnel already available for the year. Hence, this amount is determined endogenously within the submodel. Flying support outputs, related to services such as maintenance, communications, and air traffic control applicable to all flying missions attached to a base, are defined in terms of man-hours of service per month that must be furnished for all the aircraft at the base. Finally, base support outputs, reflecting services such as administration, fire protection, and ground transportation that are provided to all the personnel at a base, are computed as a function of the other missions attached to the base in the mission plan. A detailed list of the missions included in the prototype is presented in Table 3.

Manning standards are functions that translate mission specifications into required manning levels by skill and grade. There is a separate set of manning standards associated with each ISEM-P mission. For the most part, the standards included in the prototype have been adapted from actual Air Force manpower standards applicable to the various skills related to the missions. Combining the mission specifications for each base with the manning standards for the specified missions produces the manpower requirements for the base. Summing over all bases then provides the aggregate manpower requirements by skill and grade.

The second step in determining the detailed manpower authorizations involves imposing on the aggregate requirements the budgetary limitations summarized in the authorization ceilings. Whenever the total airman or officer manpower requirements exceed the corresponding authorization ceiling, establishing detailed authorizations entails reconciling the aggregate manpower requirements with the authorized end-strength. To accomplish this reconciliation, priorities based on the relative importance of the different types of missions are employed to award authorizations in excess of the minimum permissible manning levels to the various personnel groups partitioned by skill and grade. Authorizations are then allocated to bases in proportion to the relative contribution of each base to the aggregate manpower requirements.

The next activity in the aggregate planning phase consists of assessing how closely the inventory expected to exist at the end of the simulated year conforms to the detailed authorizations. This assessment is accomplished by applying the exogenous separation rates to the initial inventory to compute anticipated attrition and, hence, to derive the inventory projected to evolve in the absence of any compensatory AFMPS actions.

Table 3: ISEM-P Missions

Mission Type	Mission	Output	Type of Aircraft or Service
Flying	Strategic bombing	Flying hours/month	B-52 squadron
	Aerial Refueling	Flying hours/month	KC-135 squadron
	Tactical fighter	Flying hours/month	F-4 squadron
	Tactical reconnaissance	Flying hours/month	RF-4 squadron
	Tactical fighter/bomber	Flying hours/month	F-111 squadron
	Military airlift	Flying hours/month	C-141 squadron
	Tactical airlift	Flying hours/month	C-130 squadron
Training	Undergraduate pilot training	Students/month	T-37/T-38 squadron
	Technical training	Students/month	Technical school instruction
	Initial training	students/ month	Basic Military Training/Officer Training School instruction
Flying support	Flying support	Work-hours/month	Maintenance, munitions, communications, etc.
Base support	Base support	Work-hours/month	Administration, supply, transportation, etc.

Then, the submodel determines the promotions required to counteract the anticipated attrition losses and to adjust for any changes introduced in the mission plan for the current year relative to the plan for the preceding year. First, the overall pool of personnel eligible for promotion in each grade is computed by summing over all skill codes the projected inventory in all eligible year groups for that grade. Next, the rate at which eligible personnel must be promoted out of each grade to accommodate demands for promotions at all higher grades is derived. Third, to simulate the equal promotion opportunity policy, the number of personnel eligible for promotion in each skill at each grade is multiplied by the promotion rate calculated for that grade to establish the aggregate promotion plan for the year. Finally, a promotion plan for each month of the year is created. Specifically, the exit distribution -- the proportion of total separations occurring in each month -- is used to determine the number of promotions to be made in the month. In this manner, promotions are timed to replace anticipated attrition losses as they arise.

The last activity in the planning phase is the development of training and recruiting plans. Projected vacancies in Grade 3 must be filled by technical school graduates. Technical school entrants, in turn, must be supplied from the initial training schools: Basic Military Training (BMT) and Officer Training School (OTS). Finally, BMT and OTS entrants must be provided by recruiting.

Each school in this training sequence takes some amount of time to train its students. Therefore, to assure the delivery of graduates at the times when they are needed in Grade 3, the aggregate submodel schedules students' entry into schools at appropriate times to accommodate all required training. Travel times between bases are assumed to be negligible during the planning phase.

Because training beginning in one year may fill a promotion demand in a subsequent year, training demands for periods beyond the current simulated year must be computed when establishing training plans for that year. Therefore, in each simulated year, the aggregate submodel computes inventory projections and promotion plans for enough years beyond the current year to establish all current training demands. Summing these demands over all airmen and all officer skills generates recruiting requirements for each month during the simulated year.

At the conclusion of the planning phase, the aggregate submodel initiates its flow phase, in which the actual inventory is changed on the basis of both planned and unplanned events. First, actual attrition losses are deleted from the inventory. Because projections of personnel attrition are seldom perfectly accurate, actual separations are allowed to differ from expected losses by some variance factor. This deviation between anticipated and realized attrition will affect planning in subsequent simulated years.

Next, the planned promotions in each skill and grade are distributed across year groups in conformance with Air Force promotion policy; and the resultant detailed promotion plan is applied to the inventory. If, in any skill and grade, some year group contains fewer personnel than the number indicated for promotion, the residual promotions are drawn from lower year groups.

After promotions have been awarded, the inventory is aged by one year. Aging is accomplished by transferring the contents of each cell, for each skill and grade, to the cell corresponding to the next higher year group.

Then, aggregate procurement and training flows are simulated. In the aggregate submodel, it is assumed that all recruiting demands will be fulfilled, all new trainees will graduate, and all entry level vacancies will be filled by the end of each simulated year. Thus, all graduations from each school are totalled for all months and entered in the appropriate skills, grades, and year groups in the inventory.

Finally, Air Force personnel may be induced to volunteer to change occupational specialties. This adjustment often involves a certain amount of formal training to learn new skills. In ISEM-P, only airmen personnel are capable of lateral moves between skills, and all such moves are assumed to require cross-training.

Cross-training sources are identified as skills having surpluses relative to their authorizations, while cross-training sinks are skills experiencing shortages. Considering the sizes of all shortages and surpluses, the maximum portion of any shortage permitted to be filled through cross-training, and the historical rate at which personnel have volunteered for cross-training, the submodel determines the total amount of cross-training provided. After allocating this total across source skills, sink skills, grades, and year groups, the inventory is adjusted to reflect the resultant cross-training flows. In ISEM-P, all cross-trainees are assumed to graduate from their appropriate schools in the sixth month of each simulated year.

At this juncture, all changes in the aggregate force structure have been simulated, and the actual inventory at the end of the year has been established. This inventory is retained as the initial inventory for the ensuing cycle of the aggregate submodel. The detailed manpower authorizations and the month-by-month promotion, training, recruiting, and cross-training plans are transmitted to the assignment submodel.

3.5 The Assignment Submodel

The assignment submodel deals primarily with the geographic distribution of personnel. It does not deal directly with Air Force programs, mission functions, manpower standards, or authorization ceilings. Rather, these considerations influence the submodel's performance only through their embodiment in the detailed manpower authorizations and personnel plans established by the aggregate submodel, and used in the assignment submodel as guides for operation. Thus, the subset of AFMPS goals and objectives explicitly simulated in the assignment submodel consist of providing people

1. Of the right kind
2. At the right place
3. At the right time
4. In sufficient quantity
5. At lowest cost

Further, in this submodel the feasibility of achieving the operative goals and objectives is explicitly restricted by only two sets of constraints:

1. Policy directives
2. Exogenous labor market forces

As stated previously, within the assignment submodel the "right kind" of personnel is delineated in terms of skill and grade, the "right place" relates to a base, and the "right time" corresponds to a simulated month. Cost minimization is reflected in simulated AFMPS decision rules that seek to control both the opportunity cost associated with personnel shortages, and the excess expenditures arising from personnel surpluses and from superfluous movements of personnel among bases.

In addition to the policy directives embodied in the authorizations and plans transmitted from the aggregate submodel, four other notable AFMPS policies are incorporated in the assignment submodel. Rotation policy establishes restrictions on the maximum permissible length of time personnel may serve at overseas bases. In addition, time-on-station policy specifies the minimum allowable tour length for personnel residing at CONUS bases. Third, in each skill and grade experiencing an overall shortage or surplus of trained personnel, world-wide manning level policy governs the sharing of that surplus or shortage among bases. Finally, inter-base transfer policy defines

the order in which different categories of personnel are selected for assignment to CONUS and overseas bases. The simulated decision rules included in the assignment submodel contain representations of all four of these policy directives.

In this submodel, as stated previously, the population of personnel at each base is described by a two-dimensional array called the base supply. Each cell in the array indicates for that base the size of the group possessing the skill and grade characteristics that index the cell. Personnel in training are accounted for in the enrollment of the school they are attending. Schools are located at particular bases, but their enrollments are not included in the base supplies of those bases.

The purpose of the assignment submodel is to simulate the decision procedures that produce the assignment orders that cause personnel to be transferred between bases. In most instances, inter-base transfer decisions are based on deviations that arise between base supplies and the authorizations at the bases. Each ISEM-P base has an authorization, determined by the aggregate submodel during its planning phase, that specifies the desired number of personnel in each skill and grade that should be present at the base at the end of each simulated year.

Deviations between base supplies and authorizations can occur in the prototype for several reasons. First, a portion of the separations computed for a year are deleted from base supplies in each month. Since personnel entering and leaving the Air Force actually enter and leave at specific bases, these personnel flows are treated as assignments in ISEM-P.

Second, assignments of cross-trainees to schools affect base supplies as personnel are transferred from supplies to school enrollments. Assignments of students to schools are based on the school entry schedules developed by the aggregate submodel.

Third, authorizations may change, either because the mission plan or authorization ceilings have changed, or because of special assignment instructions that are introduced exogenously as representations of certain extraordinary assignment sequences, such as those involved in closing a base. Special assignment instructions might specify, for example, that particular inter-base transfers, changes in authorizations, or modifications of required tour lengths should be performed in particular months. In the absence of such instructions, base authorizations for each month in a simulated year are the same as the authorization for the end of the year.

Finally, some bases represented in the prototype have restrictions on the maximum length of time that personnel may serve there. Consequently, in each month the portions of the corresponding base supplies that have reached these limits must be rotated to other

locations. In ISEM-P, only the four overseas bases are assumed to have maximum tour length restrictions.

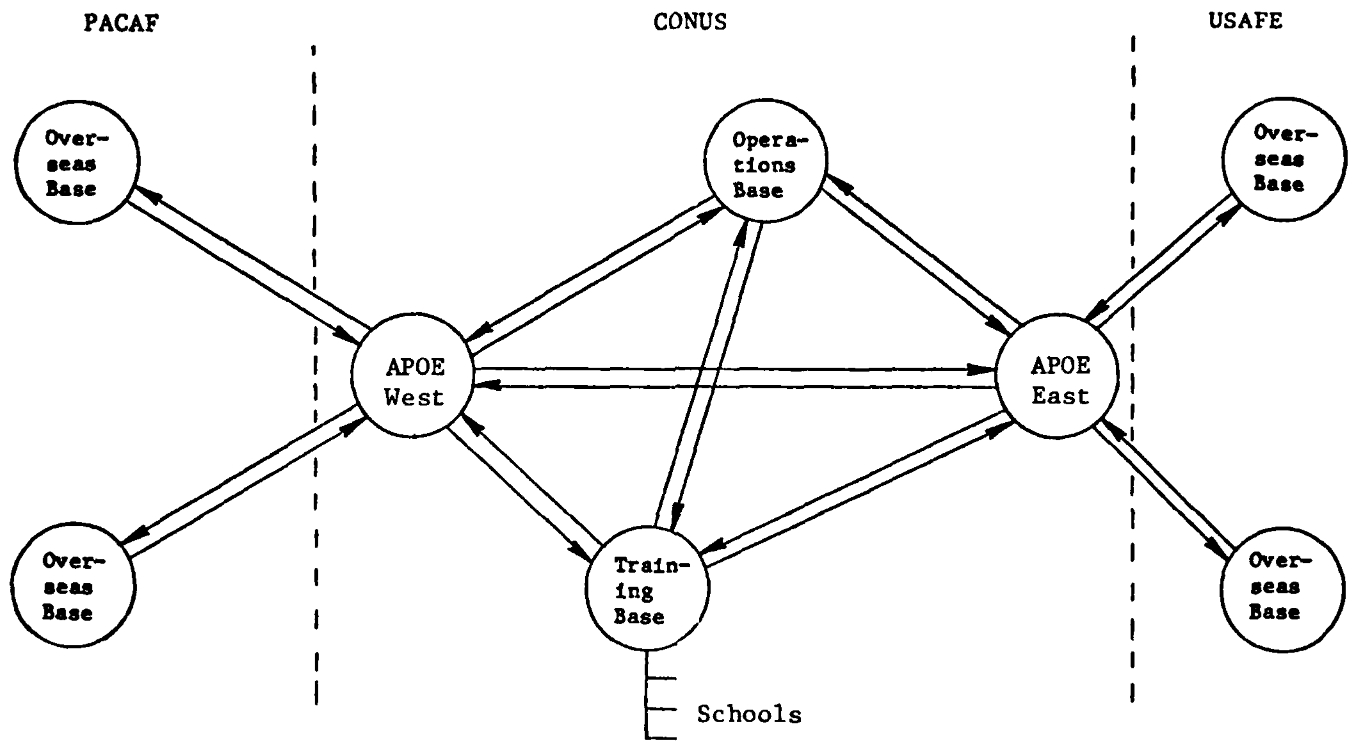
To eliminate deviations of base supplies from authorizations arising from any of these sources, the assignment submodel produces appropriate assignment orders and then executes the orders on the actual pool of personnel. Execution of an assignment order effects the flow of a group of personnel through a school or from one base to another.

At any instant during the operation of the assignment submodel, any personnel not included in base supplies are either in a travel pipe or a training pipe. A simplified depiction of the travel pipe network is presented in Figure 5. Personnel flow channels between bases are represented as uni-directional travel pipes in the prototype and are depicted as arrows in the figure. Travel pipes are the means by which personnel are transferred between bases. Thus, essentially, each travel pipe connects one base to another.

Each pipe has an associated travel time and capacity that governs its sustainable flow. Travel times are measured in days. Consequently, transferred personnel normally arrive at their destinations only a small fraction of a month after they enter a pipe. Travel pipes are used to account for the effects of travel delays on base supplies.

The CONUS bases are completely interconnected by travel pipes. However, to reach an overseas base, a group must flow through the appropriate Aerial Port of Embarkation (APOE) base. If the group's trip does not originate at an APOE, the trip consists of two legs, one to reach the APOE and one to continue overseas. Schematic diagrams of typical CONUS and overseas travel pipe flows appear in the upper portion of Figure 6.

Training pipes are similar to travel pipes, except that entry to and exit from any training pipe occur at the same base. For convenience in computing manpower requirements, it has been assumed in the prototype that initial BMT or OTS training, Technical School Training (TST), and Undergraduate Pilot Training (UPT) are performed at separate CONUS bases, with one base conducting each type of training. Thus, the training pipes are located at particular bases, and represent Air Force training facilities. Moreover, the training bases are distinct from the operations bases that perform the flying missions. As a direct consequence of this structure, in ISEM-P new personnel enter the Air Force at the initial training base, proceed to the TST base or UPT base as appropriate, and then are assigned to duty at an overseas or CONUS base. Schematic diagrams of this flow and of a typical cross-training flow are presented in the lower portion of Figure 6.



Each base has:

- A base supply
- An authorization

Each school has:

- An enrollment
- An entry schedule
- A capacity
- A training time

Each travel pipe has:

- A capacity
- A travel time

Figure 5. Geographic distribution of bases.

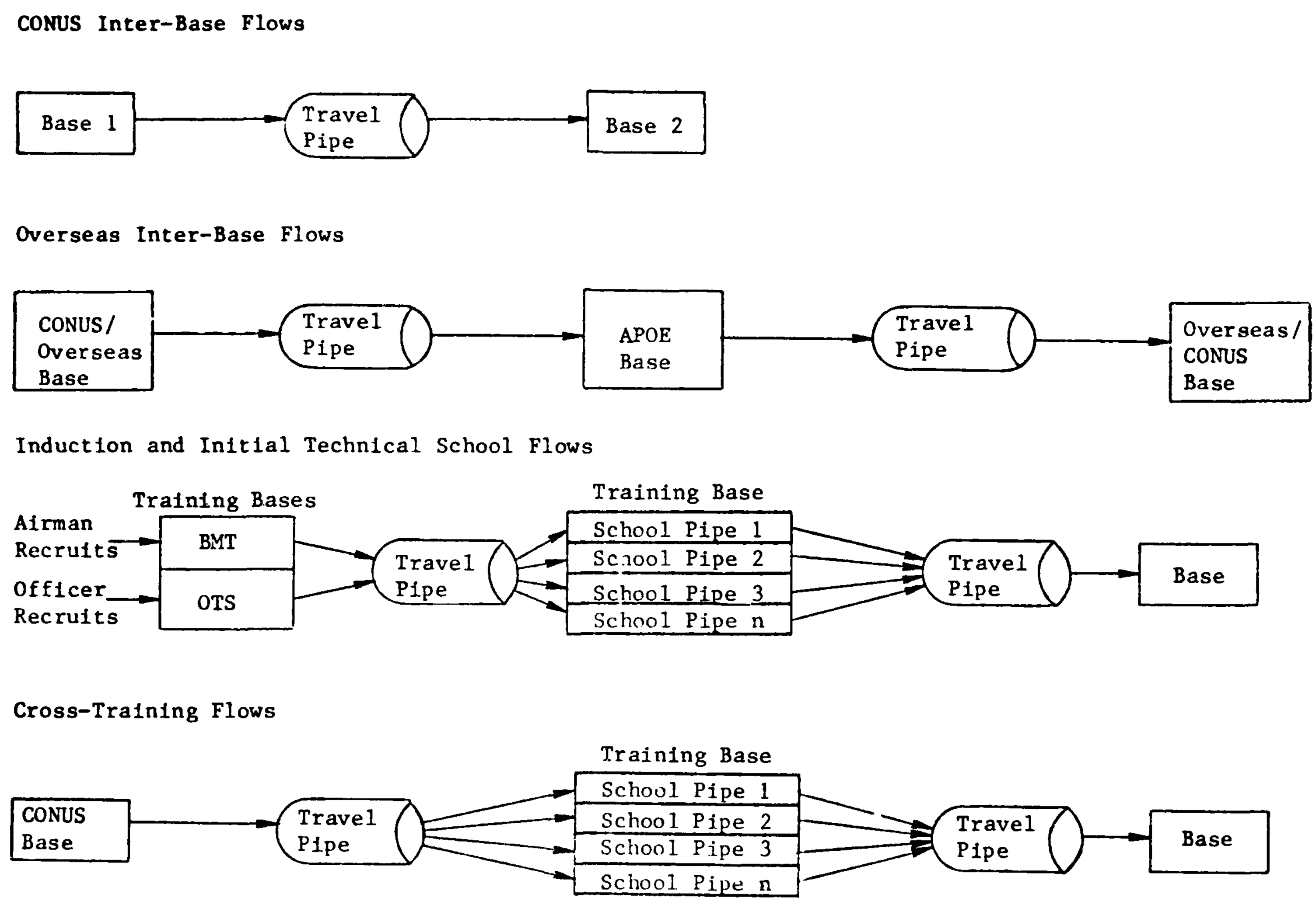


Figure 6. Typical travel and training pipe flows.

Each training pipe is characterized by a purpose, a capacity, and a training time. The purpose specifies the consequence of graduating from the school: the acquisition of a new skill. There are separate training pipes for most of the skills in the prototype. Further, there are two additional training pipes for personnel attending BMT and OTS.

The capacity indicated for a training pipe expresses the maximum enrollment per instructor permitted at the school at any one time. The number of instructors attached to each school is determined endogenously within the prototype. Hence, the total capacity of each training pipe is also derived endogenously within ISEM-P.

The training time is the duration of the course taught at the school, and is measured in months. In skills for which, in reality, there is no formal technical school training program, direct duty assignments occur. In the prototype, the training time for each of these skills is equated to zero. In effect, duty assignments for personnel in these skills are made from null schools as soon as trainees arrive there from the initial training base. Thus, operationally, training pipes are used to account for the time required to train personnel to perform mission functions.

The purpose of each type of personnel flow represented in the assignment submodel is summarized in Figure 7. Several additional simplifying assumptions embodied in the prototype are revealed in this figure. In particular, it is assumed that only personnel at CONUS bases volunteer for cross-training, and that all separations occur at CONUS bases. In addition, the personnel flow labelled overseas reassignment can be generated only by special assignment instructions. In the absence of such instructions, the only transfers out of overseas bases consist of rotations at the completion of single tours of duty.

Like the aggregate submodel, the assignment submodel operates in both a planning phase and a flow phase. In each simulated month, the planning phase creates assignment orders based on its projection of base supplies for the horizon period nine months in the future. The flow phase then executes the assignment orders established 9 months earlier for the current month.

The first activity performed in the planning phase in each month consists of entering into the submodel any special assignment instructions specified exogenously for the month. Then, in conformance with the instructions, assignment orders are produced for all mandated transfers; and all stipulated changes in authorizations and in required tour lengths are implemented in the corresponding data structures and simulated decision rules.

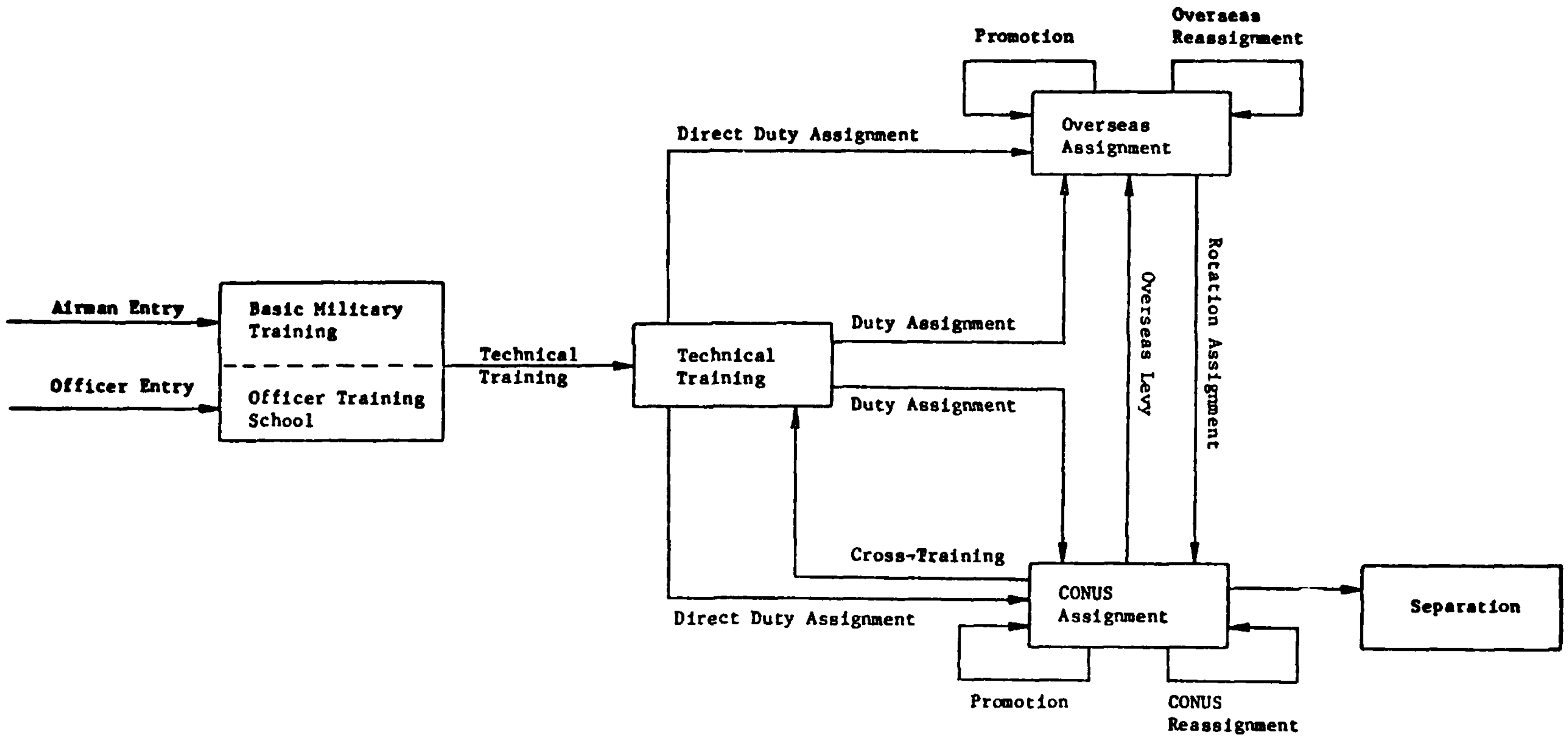


Figure 7. Assignment submodel stocks and flows.

Next, starting with the projection developed in the preceding simulated month forecasting base supplies at the beginning of the horizon period, the assignment submodel extrapolates a new projection reflecting the changes in base supplies over which assignment planners have little control: separations, promotions, volunteers for cross-training, and the predicted rotation of personnel who have completed overseas tours. First, the separations expected to occur in each skill and grade during the horizon period are computed by applying the factor for that month from the exit distribution to the separations predicted for the simulated year by the aggregate submodel. The resultant forecasts are then allocated to individual bases in proportion to the projected population in each skill and grade at each base for the horizon period.

Next, the expected promotions in each skill and grade are estimated for each base. Specifically, the monthly promotion plan developed in the aggregate submodel is distributed among bases, as with separations, in proportion to the projected populations at the bases.

Third, the personnel predicted to volunteer for cross-training are scheduled for entry into technical schools. The training plans formulated in the aggregate submodel are examined to determine the cross-training assignments scheduled for each training school in the horizon period. Then, among the personnel groups predicted to experience surpluses, the submodel selects the particular skills and grades from which the cross-trainees will be obtained. In each of these skills and grades, cross-trainees are withdrawn from CONUS bases in proportion to their base supplies.

Finally, personnel expected to rotate from overseas bases are deleted from projected overseas base supplies. The expected amount of rotation in the horizon period is estimated on the basis of distributions of the proportions of base supplies scheduled to complete overseas tours in each period. Since different bases have different maximum permissible tour lengths, a separate distribution is maintained in the prototype for each specified tour length. The resultant rotation forecast is added to a pool of personnel -- partitioned by skill, grade, base, and month of rotation -- who are expected to return from overseas and, hence, require new CONUS assignments.

After forecasting the base supplies anticipated in the absence of any discretionary action, the assignment submodel proceeds to simulate the major decisions routinely made by the AFMPS in allocating personnel to bases. The sequence of actions taken by the submodel is intended to correspond to the order in which decisions are actually made over time as the AFMPS plans personnel assignments for a particular month. In ISEM-P, assignment orders are developed independently for each personnel group differentiated by skill and grade.

First, to compensate for any overall personnel surplus or shortage, the total manpower authorization for a skill and grade is adjusted for the world-wide manning level to obtain the entitlement for that personnel group. Specifically, if an overall shortage is anticipated, each base authorization is multiplied by the ratio of the total projected Air Force population to the total authorization in that skill and grade to determine the base entitlement. Conversely, if an overall surplus is forecast, the entitlement of each overseas base is set equal to its authorization, and each CONUS base authorization is multiplied by the ratio of the remaining unappropriated projected Air Force population to the total CONUS authorization for each skill and grade to derive the entitlements for the CONUS bases. This process ensures that overseas bases are never overstaffed in any skill or grade.

Next, the base supply projections extrapolated earlier are subtracted from the corresponding base entitlements to compute the effective demands for personnel. Each effective demand indicates the number of additional personnel in some skill and grade required to fulfill an entitlement at some base.

Finally, assignment orders are created to satisfy the effective demands. Four distinct sources of personnel supplies are considered sequentially by the submodel.

First, effective demands at overseas bases are filled from projected CONUS base supplies. Personnel eligible for overseas tours must have resided in the CONUS longer than the minimum permissible time, normally 24 months. In each skill and grade, personnel are selected from CONUS bases in proportion to the eligible populations at the bases. Effective demands in excess of the total number of eligible personnel are not filled at this time.

Then, to the extent possible, assignment orders are established for personnel expected to return from overseas tours. Specifically, effective demands at CONUS bases are filled from the previously discussed rotation pool containing the number of personnel in each skill and grade available for reassignment from each overseas base in each month between the current month and the horizon period. Personnel available in earlier months receive assignment orders before personnel available in later periods.

Next, projected future training school graduates are allocated to the bases. Records for such graduates are maintained in technical training pools, indicating the number of trainees currently in technical schools who have not yet received the assignments they will perform after graduation. Effective demands at overseas bases have priority over effective demands at CONUS bases when graduates are distributed from these pools. As assignment orders are generated, they are filed in the queues of dispositions for the associated schools.

As trainees graduate, the dispositions are honored in the order in which they were filed. Thus, technical school graduates might not augment actual base supplies in the month for which they were added to projected base supplies.

Finally, if any unfilled CONUS demands remain, the submodel attempts to fulfill the demands from CONUS bases. To be an acceptable source for a transfer of personnel between CONUS bases, a base must have (a) a surplus of personnel in the demanded grade; (b) a surplus of personnel in the demanded skill, regardless of grade; and (c) personnel eligible for reassignment through their residence at the base for more than the minimum allowable time-on-station, normally 36 months.

If the total number of eligible personnel at all bases exceeds the total effective demand, assignment orders are distributed among bases in proportion to the number of eligible personnel at each base. If the total supply is less than the total demand, eligible personnel are allocated in proportion to the effective demand at each base. If the two totals are equal, all demands are fulfilled using all eligible personnel.

At the conclusion of the planning phase, the assignment submodel initiates its flow phase, in which the assignment orders and personnel dispositions created in the planning phase are implemented. In this phase, the submodel simulates the movements of personnel through travel and school pipes, and the consequent adjustments in base supplies, that have been prescribed during the planning phase.

Before any established assignment orders are executed, however, two preliminary activities are performed. First, if actual separations differ from expectations, all projections made on the basis of the expected separations are revised to conform to reality. Thus, the submodel investigates whether any personnel scheduled to rotate from overseas bases during the current simulated month have not yet been reassigned to duty at CONUS bases. Whenever this situation prevails, an attempt is made to find current personnel shortages in appropriate skills and grades in the CONUS. If any such shortages are found, uncommitted personnel are assigned to the associated CONUS bases in proportion to the size of the shortage at each base. Then, in accord with the world-wide manning level policy, if any personnel remain unassigned after all applicable CONUS shortages have been eliminated, the residual personnel are allocated to CONUS bases as surpluses in proportion to the authorization at each base.

After completing these preparatory actions, all assignment orders are implemented, and all resultant inter-base flows are initiated. Promotions are awarded as planned, and base supplies are adjusted accordingly. Personnel groups transferring between bases are entered into the appropriate travel pipes. New recruits for the current month

are entered into initial training school pipes, and are classified into skills in conformance with the technical school entry schedules established for the month when they will graduate from initial training. The classification is then manifested by creating dispositions at the initial training schools for the appropriate number of personnel in each skill. These dispositions subsequently direct the initial training school graduates to the technical schools providing the designated skills, just as technical school dispositions control the assignment of technical school graduates to bases.

The school dispositions established for the current month are implemented; and the corresponding personnel groups are entered into appropriate travel pipes. Whenever no disposition has been established for a group of technical school graduates, they are allocated among bases using essentially the same procedure employed to create assignment orders for uncommitted personnel returning to the CONUS from overseas bases. However, in this case, personnel may be distributed among all bases, and not just among the CONUS bases. Excess initial training school graduates are assigned randomly to available technical training schools.

Finally, when groups of personnel emerge from travel pipes at their destination bases, they are either added appropriately into base supplies, or entered into the designated schools at the bases. Upon completion of these operations, all personnel flows through schools, between and within bases, and into and out of the Air Force itself have been simulated; the actual base supplies at the end of the current month have been established; and the projected base supplies at the end of the horizon period have been estimated. These actual and projected base supplies are retained as initial descriptions of the stock of personnel for the ensuing cycle of the assignment submodel.

There are 12 monthly cycles of the assignment submodel for each yearly cycle of the aggregate submodel. The entire process is iterated through the total number of simulated years, typically five, for which input data are provided to the prototype.

4.0 CONCEPTUAL STRUCTURE OF THE SENSITIVITY ANALYSIS

The detailed discussion of the design and operation of ISEM-P presented in the preceding section clearly indicates that the descriptions of planned and realized personnel movements and force structures developed by the prototype are ultimately based on, and hence are very likely to be affected by, the large number and wide variety of assumptions contained in the model. Specifically, the outputs produced by the prototype are undoubtedly influenced, to a greater or lesser extent, by the assumptions underlying such attributes of ISEM-P as:

1. The form and content of the prototype's simulations of Air Force policy directives and AFMPS decision rules.

2. The nature of the prototype's characterizations of conditions affecting, yet largely exogenous to, the AFMPS.

3. The initial conditions relative to which the prototype initiates its simulation of AFMPS operations.

4. The scale of aggregation and degree of detail embodied in the prototype's representation of the structure of the Air Force and its stock of personnel.

In recognition of such widespread prospective sources of imprecision and inaccuracy, it is now appropriate to undertake a systematic examination of the sensitivity of the outputs produced by the prototype to the specific assumptions explicitly or implicitly incorporated within its design.

The purpose of this study is, therefore, to perform a thorough analysis of the changes observed in a variety of measures or indicators of the prototype's performance that result from methodical adjustments of the values of particular parameters associated with key model structure issues. It is important to realize at the outset, however, that the sensitivity analysis developed in this study is capable only of examining the reliability of the prototype's simulation of the AFMPS, but is unavoidably inadequate to assess the accuracy of the simulation. Because of the extreme disparity between the scale of ISEM-P and the size of the Air Force, it has been impossible to develop sufficiently analogous data to permit valid comparison of the simulated performance of the prototype with the actual behavior of the AFMPS for any situation. Consequently, all comparisons made in this study consist of examinations, for identical operational situations, of differences in the performance of the prototype under systematically different sets of parametric assumptions.

Such contrasts, regrettably, provide no indication of the realism of the outputs generated by the prototype, for any set of parameter values, as descriptions of the behavior of the AFMPS in any situation. The comparisons do, however, supply clear evidence of the relative responsiveness of ISEM-P to adjustments in the values of its various structural parameters. Thus, they indicate the components of the model in which it is empirically important to establish accurate representations of AFMPS decision rules and operating conditions, and, conversely, the elements for which, over a reasonably broad range, the specific values assigned to parameters have relatively little impact on the performance of the prototype.

4.1 The Issues Examined

Overall, assessments of the relative sensitivity of the performance of ISEM-P to changes in the values of 11 distinct sets of parameters have been conducted. Within most of these sets, multiple changes in parameter values, frequently for more than one parameter, have been examined. Moreover, as indicated previously, the changes studied can be meaningfully grouped into four basic categories.

Thus, within the context of this categorical framework, the specific model structure issues investigated in this study consist of:

1. Analyses of the form and content of ISEM-P's representations of Air Force policy directives and AFMPS decision rules, where the changes in parameter values examined are:

    - Increases and decreases of 20 percent in six principal mission specifications or manning standards, including:

        - Standard flying hours -- the amount of flight time that a squadron of aircraft attached to a particular mission is expected to produce during a month. This parameter directly influences the calculations of manpower requirements for aviators.

        - The flight plan coefficient -- the number of flight plans that a squadron is expected to generate per hour of flight time produced. This attribute directly affects the determination of manpower requirements for air operations personnel.

- The munition load factor -- the quantity of munitions maintained in inventory as a proportion of the standard munition load of an aircraft attached to a particular mission. This property is a prime determinant of the manpower requirements for munitions/weapons control systems personnel.

- The maintenance manpower factor -- the portion of a standard work day during which maintenance personnel normally are directly involved in productive maintenance activity. This parameter contributes directly to the computation of manpower requirements for maintenance personnel.

- The work load factor -- the amount of electronic communications repair activity required at a base in relation to the total quantity of aircraft and other equipment attached to the base. This coefficient is a principal element in the calculation of manpower requirements for communications/weather personnel.

- Base support coefficients -- factors expressing the manpower requirements for various types of base support personnel as percentages of the total population of a base.

– Reductions of the minimum permissible time-in-CONUS prior to reassignment overseas, and the minimum allowable time-on-station prior to reassignment within the CONUS, from their basic values of 24 months and 36 months, respectively. Specifically:

  - Reductions of both requirements by 6 months, to 18 months for time-in-CONUS and 30 months for time-on-station.

  - Reductions of both requirements by 12 months, to 12 months for time-in-CONUS and 24 months for time-on-station.

– Modifications of the length of the planning horizon employed in the assignment submodel from its normal value of 9 months, including:

  - A 2-month extension of the assignment planning horizon to 11 months.

- A 2-month compression of the assignment planning horizon to 7 months.

2. Examinations of the nature of ISEM-P's characterizations of essentially exogenous conditions affecting the AFMPS, where the parameter adjustments investigated are:

   - Changes in personnel retention rates -- the rates at which personnel choose not to separate from the Air Force -- from their historically observed values in each year group and grade. In particular:

     - Increases in the retention rates of all personnel groups by 20 percent, or to the maximum feasible value of 1.0, whichever is smaller.

     - Decreases of the retention rates of all personnel groups by 20 percent.

   - Increases in the amount of time required for travel between bases. Specifically:

     - Extension of the travel times associated with all travel pipes by a factor of two.

     - Extension of the travel times associated with all travel pipes by a factor of three.

3. Investigations of the initial conditions defining the composition of the prototype's stock of personnel at the beginning of a simulation, where the changes analyzed include:

   - Replacement of an initial personnel distribution partitioned by year group that has been derived from historical data, with an equivalent distribution reflecting the Air Force's established force structure objectives.

   - Replacement of an initial personnel distribution partitioned by grade that has been derived from historical data, with an equivalent distribution developed from the Air Force's adopted force structure objectives.

4. Inquiries into the scale of aggregation and degree of detail contained in ISEM-P's representations of the organizational structure and personnel stocks, where the modifications studied are:

- Reductions of the number of bases in the prototype by deleting the representation of different individual bases in separate simulations. The specific modifications examined include:

  - Deletion of Base 6, a TAC operations base in the CONUS. Since this base accommodates precisely the same missions as Base 13, this analysis also comprises an investigation of the deletion of Base 13.

  - Deletion of Base 7, a SAC operations base in the CONUS. Because of their identical missions, this analysis also constitutes an examination of the deletion of Base 8 or Base 9.

  - Deletion of Base 12, a TAC operations base in the CONUS.

  - Deletion of Base 14, an operations base in Europe.

  - Deletion of Base 15, the second operations base in Europe.

  - Deletion of Base 16, an operations base in the Pacific.

  - Deletion of Base 17, the second operations base in the Pacific.

  The three ATC bases -- Base 1, Base 2, and Base 3 -- have not been deleted because their distinct training missions make each base a unique source of supply for personnel in different skills. Similarly, Base 10 has not been deleted because it is the only CONUS base accommodating a flying mission also attached to overseas Bases 15 and 16. Without Base 10, rotation of personnel would be impossible for several skills. Finally, the two APOE bases -- Base 4 and Base 5 -- have not been deleted because of their crucial roles in the prototype's grid of travel pipes.

- Increases in the scale of the organizational units represented in the prototype by selectively combining the mission specifications for different bases. The base combinations analyzed include:

    - Aggregations of the two sets of identical bases in the CONUS -- TAC Bases 6 and 13, and SAC Bases 7, 8, and 9 -- to produce representations of only 14 bases in the prototype.

    - Consolidation of CONUS bases in the same major commands -- MAC Bases 4 and 10; TAC Bases 6, 11, 12, and 13; and SAC Bases 7, 8, and 9 -- into integrated organizational units, creating representations of just 11 bases in the prototype.

    - Combination of Bases 4 through 13 -- all CONUS bases except the three ATC bases -- resulting in representations of only eight bases in ISEM-P.

- Decreases in the degree of detail embodied in the skill categories characterized in ISEM-P by selectively combining the skill classifications listed in Table 1. Three different consolidations of skill classifications have been performed, resulting in:

    - Reductions in the number of airman skill categories to 36, and the number of officer skill categories to 25.

    - Further decreases in the numbers of airman and officer skill categories to 29 and 19 respectively.

    - Ultimate reductions in the numbers of skill categories to 19 for airmen and 12 for officers.

  The precise compositions of these aggregations of skill classifications are presented in Table 4.

- Reduction of the time period for which a simulation is conducted from 5 years to 3 years.

Thus, a total of 36 different adaptations of the values of structural parameters of ISEM-P have been undertaken for the sensitivity analyses conducted in this study. These adaptations are summarized briefly in Table 5.

Table 4: Consolidated Skill Categories

AIRMAN SKILLS

Minor Consolidation

Revised Skill Category	Function	Original Skill Code(s)
1	Aerial gunner	1
2	Aircraft logistics	2, 3
3	Intelligence	4
4	Photomapping	5
5	Weather	6
6	Air operations	7
7	Air traffic controller	8
8	Detection and deployment	9
9	Communications equipment operation	10, 11
10	Weather equipment repair	12
11	Radar equipment repair	13
12	Communications equipment repair	14, 16, 26
13	Computer systems repair	15
14	Weapons system maintenance	17, 18, 19
15	Flight system maintenance	20, 21, 22
16	Instrument trainer	23
17	Defensive systems trainer	24
18	Navigation, bombing, and tactics trainer	25
19	Aircraft structural repair	27, 36
20	Propeller aircraft repair	28, 31
21	Jet aircraft repair	29, 30
22	Munitions maintenance	31
23	Weapons mechanic	33
24	Ground transportation	34, 40
25	Computer systems operator	35
26	Base maintenance	37, 38, 39
27	Supply and food services	41, 43
28	Fuel service	42
29	Procurement	44
30	Accounting and finance	45
31	Administration	46
32	Manpower-personnel	47
33	Training support	48
34	Security police	49
35	Medical-dental	50
36	Aircrew protection	51

Moderate Consolidation

Revised Skill Category	Function	Original Skill Code(s)
1	Aerial gunner	1
2	Aircraft logistics	2, 3
3	Intelligence and photomapping	4, 5
4	Weather	6
5	Air operations	7
6	Air traffic controller	8
7	Detection and deployment	9
8	Communications equipment operation	10, 11
9	Weather equipment repair	12
10	Radar equipment repair	13
11	Communications equipment repair	14, 16, 26
12	Computer systems	15, 35
13	Weapons system maintenance	17, 18, 19
14	Flight system maintenance	20, 21, 22
15	Flight trainer	23, 24
16	Navigation, bombing, and tactics trainer	25
17	Aircraft structural repair	27, 36
18	Propeller aircraft repair	28, 31
19	Jet aircraft repair	29, 30
20	Munitions maintenance	32
21	Weapons mechanic	33
22	Ground transportation	34, 40
23	Base maintenance	37, 38, 39
24	Base logistics	41, 42, 43, 44
25	General administration	45, 46, 47
26	Training support	48
27	Security police	49
28	Medical-dental	50
29	Aircrew protection	51

Major Consolidation

Revised Skill Category	Function	Original Skill Code(s)
1	Direct aircraft support	1, 2, 3, 51
2	Intelligence and photomapping	4, 5
3	Weather	6
4	Air operations	7
5	Air traffic controller	8
6	Detection and deployment	9
7	Communications	10, 11, 14, 16, 26
8	Weather equipment repair	12
9	Radar equipment repair	13
10	Base support	15, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49
11	Avionics maintenance	17, 18, 19, 20, 21, 22
12	Flight trainer	23, 24
13	Navigation, bombing, and tactics trainer	25
14	Aircraft structural repair	27, 36
15	Aircraft operation repair	28, 29, 30, 31
16	Munitions maintenance	32
17	Weapons mechanic	33
18	Training support	48
19	Medical-dental	50

Table 4 (continued)

OFFICER SKILLS

Minor Consolidation			Moderate Consolidation			Major Consolidation		
Revised Skill Category	Function	Original Skill Code(s)	Revised Skill Category	Function	Original Skill Code(s)	Revised Skill Category	Function	Original Skill Code(s)
37	Pilot	52	30	Pilot	52	20	Aviator	52
		53			53			53
		54			54			54
		55			55			55
		56			56			56
		57			57			57
		58			58			58
38	Navigator	59	31	Navigator	59			59
		60			60			60
		61			61			61
		62			62			62
		63			63			63
		64			64			64
		65			65			65
39	B-52 electronic weapons officer	66	32	B-52 electronic weapons officer	66			66
40	Air traffic controller	67	33	Air traffic controller	67	21	Air traffic controller	67
41	Weapons control	68	34	Weapons control	68	22	Weapons control	68
42	Weather	69	35	Weather	69	23	Weather	69
43	Communications-electronic systems	70	36	Communications-electronic systems	70	24	Communications-electronic systems	70
44	Computer maintenance	71	37	Computer systems	71	25	Base support	71
45	Aircraft avionics maintenance	72			74			74
46	Munitions	73	38	Aircraft avionics maintenance	72			75
47	Computer technology	74	39	Munitions	73			77
48	Civil engineering	75	40	Civil engineering	75			78
49	Chartography	76	41	Intelligence and chartography	76			79
50	Transportation	77			85			80
51	Supply	78	42	Transportation	77			81
52	Fuels	79	43	Base logistics	78			82
53	Procurement	80			79			83
54	Finance	81			80			86
55	Administration	82	44	General administration	81	26	Aircraft avionics maintenance	72
56	Personnel-manpower	83			82	27	Munitions	73
57	Education-training	84			83	28	Intelligence and chartography	76
58	Intelligence	85	45	Education-training	84			85
59	Security police	86	46	Security police	86	29	Education-training	84
60	Medical-dental	87	47	Medical-dental	87	30	Medical-dental	87
		88			88			88
		90			90			90
		91			91			91
61	Nurse	89	48	Nurse	89	31	Nurse	89

Table 5: Issues Examined in the Sensitivity Analysis

Attribute Category	Parameter Set	Sensitivity Issue
Representations of policy directives and decision rules	Missions specifications and manning standards	Increase standard flying hours Decrease standard flying hours Increase flight plan coefficient Decrease flight plan coefficient Increase munition load factor Decrease munition load factor Increase maintenance manpower factor Decrease maintenance manpower factor Increase work load factor Decrease work load factor Increase base support coefficients Decrease base support coefficients
	Time-in-CONUS/time-on-station (TIC/TOS) requirements	Reduce TIC/TOS requirements 6 months Reduce TIC/TOS requirements 12 months
	Planning horizon for personnel assignments	Increase assignment planning horizon Decrease assignment planning horizon
Characterization of exogenous conditions	Personnel retention/separation rates	Increase retention rates Decrease retention rates
	Travel times between bases	Double travel times Triple travel times
Initial composition of personnel stock	Personnel distribution by year group	Change year group distribution
	Personnel distribution by grade	Change grade distribution
Scale of aggregation and degree of detail	Number of bases	Delete Base 6 Delete Base 7 Delete Base 12 Delete Base 14 Delete Base 15 Delete Base 16 Delete Base 17
	Scale of organizational units	Combine identical CONUS bases Consolidate CONUS MAJCOMs[a] Consolidate non-ATC CONUS bases
	Degree of detail in skill categories	Minor skill consolidation Moderate skill consolidation Major skill consolidation
	Duration of simulation	3-year simulation

[a]Major Commands

4.2 Basic Analytic Approach

To analyze the sensitivity of the performance of ISEM-P to the various changes in parameter values described in the preceding section, the outputs generated by the prototype for each modified specification of parameter values have been systematically compared to analogous outputs derived for the initial specification of parameter values. In addition, to assess the degree to which the relative responsiveness of the prototype's performance to particular changes in parameter values might vary for simulations of different operating environments, comparisons have been made within the context of five different baseline scenarios corresponding to five contrasting operational situations. Thus, for virtually all of the revised specifications of ISEM-P parameter values, separate comparisons have been conducted for five distinct baseline scenarios.

The first baseline scenario employed in the sensitivity analysis describes a situation in which the mission plan and authorization ceilings are identical for all years of the simulation. Moreover, the authorization ceilings are equated to the total manpower requirements for airmen and for officers. Consequently, this scenario corresponds to an operational situation in which no external stress is imposed upon the AFMPS throughout the time period under consideration.

In the second baseline scenario, ISEM-P simulates the closing of Base 16, one of the two PACAF bases represented in the prototype. During the second year of the simulation, the missions initially attached to Base 16 are reassigned to Base 17, the other PACAF base included in ISEM-P. Personnel are then transferred appropriately to achieve the relocation of the missions. Thus, closing a base primarily affects the assignment submodel, which must respond to a geographic shift in the placement of missions by redistributing base supplies to conform to revised base authorizations.

In a real base closure situation, the AFMPS carefully strives to control the timing of personnel reassignments. To assure uninterrupted readiness throughout the relocation interval, different categories of personnel are transferred between bases in a specific preplanned order. Essentially, mission support personnel relocate first; direct mission personnel, and equipment, follow; and base support personnel are transferred last.

This pattern is simulated in the ISEM-P base closure scenario by reassigning the mission support personnel of Base 16 during the first 3 months of the second year, and then relocating the direct mission personnel and the base support personnel during the third through the fifth months of the year. This sequence of activities is communicated to the planning phase of the assignment submodel as a series of changes in the authorizations of affected bases. By the sixth month of the

second year, Base 16 has effectively been closed since it has neither authorizations nor supplies and, hence, cannot be involved in any further assignment actions.

The third baseline scenario corresponds to a situation in which Air Force personnel budgets are repeatedly reduced. Specifically, beginning with initial authorization ceilings equal to total airman and officer manpower requirements, the ceilings established in the prototype are successively decreased by 2 percent in each subsequent year. Then, by applying the procedures contained in ISEM-P for reconciling manpower requirements with authorization ceilings, the reductions in authorizations are imposed on the base support and mission support skills, while the authorizations for the direct mission skills are maintained at their initial levels. The allocation of authorization reductions to mission support and base support skills is determined on the basis of minimum permissible manning levels of 84 percent of manpower requirements for mission support skills, and 57 percent of requirements for base support skills.

The fourth baseline scenario investigates the effects of a change in workload parameters during the course of a simulation. In this scenario, the aircraft utilization rate of all B-52 aircraft is reduced by 20 percent beginning in the second year, and continuing through the end of the simulation. This parameter indicates the amount of flight time actually produced by a typical aircraft in a B-52 squadron during one month. A reduction in this rate induces a decrease in manpower requirements and, subsequently, in personnel authorizations for associated skills, including B-52 pilots, B-52 navigators, aerial gunners, various maintenance skills, some mission support skills such as air operations, and all base support skills.

In the final baseline scenario, the prototype examines the consequences of errors in forecasts of personnel attrition for promotion, training, and recruitment planning. To perform this investigation, actual retention rates are reduced 60 percent below projected retention rates for three airman skills and one officer skill in the second year of the simulation. In all other years, and for all other skills in the second year, actual separations are assumed to correspond exactly to expectations.

Thus, in summary, the five baseline scenarios utilized as the foundations of the sensitivity analysis consist of constant authorizations, base closure, reduced authorizations, reduced aircraft utilization, and reduced retention.

5.0 SENSITIVITY ANALYSIS METHODOLOGY

Basically, the methodology used to analyze the sensitivity of the performance of ISEM-P to changes in the values of its structural parameters consists of systematically comparing the outputs produced by the prototype with its initial specification of parameter values to the outputs generated with the modified sets of parameter values corresponding to the 36 sensitivity issues, in the operational situations described by the five baseline scenarios. To implement this methodology, it is first necessary to formulate suitable measures of the prototype's performance; i.e., measures such that noticeable differences in their magnitudes derived for different specifications of parameter values indicate notable disparities in important aspects of the prototype's performance. Then, procedures must be established for methodically comparing the magnitudes attained by the measures in analogous simulations embodying systematically different specifications of parameter values, to obtain an evaluation of the sensitivity of ISEM-P to the associated changes in parameter values.

5.1 ISEM-P Performance Measures

Because ISEM-P has been designed to simulate the interactions of numerous types of decisions made by the various components of the AFMPS, no single natural indicator exists to summarize all pertinent facets of the prototype's performance. Rather, a wide variety of prospective measures of different salient aspects of ISEM-P's performance are conceivable.

Moreover, because the ultimate use of the ISEM concept within the Air Force has not yet been determined, it is currently impossible to establish any defensible priorities expressing the relative importance of the various possible disaggregated performance measures. Consequently, no single synthetic indicator can presently be formulated to summarize the disaggregated measures.

Therefore, five basic types of performance measures have been employed in this study:

1. Deviation measures, indicating the frequency and magnitude of deviations between actual stocks of personnel and manpower authorizations.

2. Mobility measures, reflecting the volume of personnel transfers involved in achieving established plans.

3. Accession/retention measures, monitoring the interactions of the AFMPS with the private labor market.

4. Training measures, appraising the training loads experienced by the initial training schools and the technical schools.

5. Status measures, describing the composition of the stock of personnel at a particular time.

Each of these types of measures can be directly related to some form of direct expenditure or opportunity cost borne by the Air Force. The deviation measures reflect both the excess expenditures associated with maintaining surplus personnel, and the opportunity costs in terms of impaired mission readiness arising from personnel shortages. The expenses involved in transporting personnel between bases are evidenced in the mobility measures. The accession/retention measures monitor the costs of labor turnover; i.e., the opportunity costs of losing skilled personnel and the outlays required to procure new personnel. The training measures indicate the direct costs of imparting new skills to personnel and the opportunity cost of, in effect, withholding personnel involved in training from operational duty. Finally, the status measures provide a basis for assessing the opportunity costs associated with differences in the levels of expertise and experience possessed by different stocks of personnel.

In addition, each type of measure has been formulated to disclose a variety of degrees of detail about the performance of the prototype. The alternative degrees of detail correspond essentially to different levels of aggregation of the basic personnel groups delineated in ISEM-P. For the deviation and mobility measures, the various degrees of detail relate to aggregations of personnel groups partitioned by skill, grade, and geographic location. Accumulations of groups differentiated by skill and grade establish the degree of detail embodied in the accession/retention measures. The detail included in the training measures creates distinctions based solely on differences in skill codes. Finally, in the status measures, the degrees of detail refer to aggregations of personnel groups distinguished by grade and year group for both airmen and officers.

The specific degrees of detail examined for all of the types of performance measures used in the sensitivity analysis are summarized in Figure 8. Thus, beginning at the highest level of aggregation, the total stock of personnel represented in ISEM-P is first divided on the basis of skill codes into two basic personnel types: airmen and officers. Next, for the deviation, mobility, and accession/retention measures, each personnel type is subdivided into three broad classes of skills: mission, mission support, and base support. Then, for all types of performance measures except the status measures, further disaggregation is performed at the level of individual skill codes.

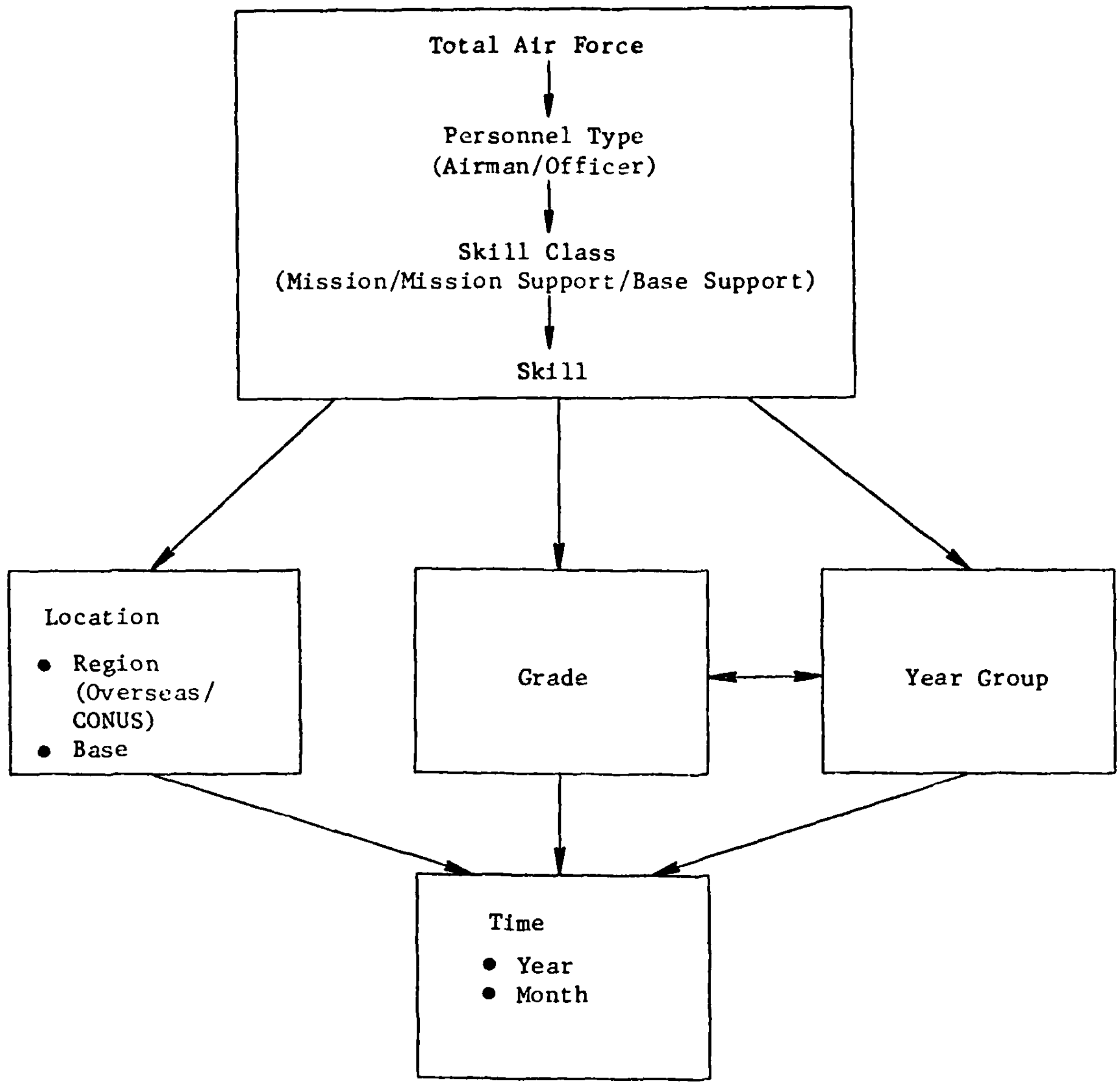


Figure 8. Degrees of detail in performance measures.

In the deviation and mobility measures, cross-tabulations are provided on the basis of geographic location for virtually all of the personnel groupings described above. With the mobility measures, the cross-tabulations are based on broad distinctions between CONUS and overseas bases; while for the deviation measures, distinctions are created among the individual bases.

A separate set of cross-tabulations is developed, in all measures except the training measures, for the different grades. Moreover, in the status measures, further cross-tabulations are established to differentiate among year groups.

Finally, for the deviation, mobility, and accession/retention measures, all indicators are derived both cumulatively throughout each simulated year, and for the last month of each year. Conversely, for the training and status measures, all indicators summarize each year as a whole.

Since many of the sensitivity issues analyzed in this study, such as the base deletion, base consolidation, and skill consolidation issues, involve changes in the scale of ISEM-P, all performance measures have been designed in forms whose values are independent of the scale of the prototype. Thus, the performance measures are predominantly defined in terms of ratios. Only a small number of measures indicate the maximum values attained by certain variables.

The deviation measures are all ultimately based on the observed differences between actual personnel stocks and detailed manpower authorizations for personnel groups partitioned by skill, grade, and base. This evidence is methodically accumulated for the more highly aggregated collections of personnel discussed above to develop indicators of the overall success of the simulated AFMPS in fulfilling its manpower authorizations. Seven different methods of accumulating the individual deviations from authorizations for all basic personnel groups within each of the more highly aggregated personnel collections have been employed in the sensitivity analysis. Each accumulation method has produced a corresponding set of deviation measures. The seven resultant types of measures are:

1. The frequency of positive deviations -- the proportion of basic personnel groups for which positive differences between actual and authorized personnel stocks, or surpluses, are observed.

2. The frequency of negative deviations -- the proportion of basic personnel groups for which negative differences between actual and authorized personnel stocks, or shortages, are observed.

3. The average positive deviation -- the average number of surplus personnel observed in the basic personnel groups experiencing positive differences between actual and authorized personnel stocks.

4. The average negative deviation -- the average size of the personnel shortage observed in the basic personnel groups experiencing negative differences between actual and authorized personnel stocks.

5. The maximum positive deviation -- the greatest number of surplus personnel observed in any of the basic personnel groups experiencing positive differences between actual and authorized personnel stocks.

6. The maximum negative deviation -- the largest personnel shortage observed in any of the basic personnel groups experiencing negative differences between actual and authorized personnel stocks.

7. The root-mean-squared deviation (RMS) -- defined as

$$RMS = \left(\sum_{i=1}^{N} \Delta_i^2 / N \right)^{1/2}, \text{ where}$$

Δ_i = the difference between the actual and authorized personnel stocks for basic personnel group i, and

N = the number of basic personnel groups included in the more highly aggregated personnel collection.

This measure attaches equal weight to all surpluses and shortages of the same size. However, proportionately greater weight is attached to large deviations than to small deviations.

The mobility measures used in the sensitivity analysis examine the number of personnel movements involved in implementing the assignment decisions made to ISEM-P to fill the detailed manpower authorizations. The general measure of personnel mobility that has been applied to the various collections of personnel described above is the Permanent Change of Station (PCS) rate -- the ratio of the number of personnel in a collection who are involved in PCS transfers among bases to the total population of the collection. Separate computations of the PCS rate are performed for transfers from the CONUS to overseas, transfers from overseas to the CONUS, transfers within the CONUS, and total transfers throughout the Air Force.

The accession/retention measures investigate the procurement of new personnel and the reenlistment of current personnel within personnel categories differentiated on the basis of skill and grade. Thus, for each personnel category of this type discussed above, the accession/retention measure calculated for the sensitivity analysis is the accession rate -- the ratio of the number of personnel enlisting or reenlisting in the category to the total stock of personnel in the category.

The training measures indicate the volume of training performed by the *initial* training schools and the technical schools, relative to the manpower authorizations of the skills served by the school. Thus, for each school, or for each combination of schools specified above, six types of training measures have been developed for use in the sensitivity analysis:

1. The ratio of the total number of personnel entering the school(s) during each simulated year, to the total manpower authorization of the corresponding skill(s) for the year.

2. The ratio of the maximum number of personnel entering the school(s) during any month in each simulated year, to the total manpower authorization of the corresponding skill(s) for the year.

3. The ratio of the total number of personnel enrolled in the school(s) during each simulated year, to the total manpower authorization of the corresponding skill(s) for the year.

4. The ratio of the maximum number of personnel enrolled in the school(s) during any month in each simulated year, to the total manpower authorization of the corresponding skill(s) for the year.

5. The number of months in each simulated year during which a queue of personnel is awaiting entry into the school(s).

6. The ratio of the maximum number of personnel delayed in a queue awaiting entry into the school(s) during any month of each simulated year, to the total manpower authorization for the corresponding skill(s) for the year.

Finally, the status measures examine the composition of the prototype's stock of personnel relative to personnel types, grades, and year groups. Specifically, four different types of measures have been developed for each simulated year:

1. The proportions of airmen and officers in the total stock of personnel.

2. Relative frequency distributions of the airman and officer populations across year groups.

3. Relative frequency distributions of the airman and officer populations across grades.

4. Relative frequency distributions of the airman and officer populations in each grade, across year groups.

Thus, for each simulated year, the composition of the personnel stock is described in terms of 15 different sets of proportions.

5.2 Sensitivity Evaluation

All of the performance measures discussed in the preceding section describe the results produced by ISEM-P in a single simulation of the behavior of the AFMPS. Evaluating the prototype's sensitivity to adjustments in the value of its structural parameters entails comparing the values attained by the various performance measures in analogous simulations. Specifically, such evaluation involves examining the differences between the magnitudes of the performance measures observed with the initial specification of parameter values, and the sizes of the same performance measures occurring with a modified set of parameter values associated with one of the 36 sensitivity issues, in a standard operational situation described by one of the five baseline scenarios.

To provide perspective to the examination of the observed differences in the magnitudes of the various performance measures -- and, in so doing, to focus the sensitivity evaluation on differences that are distinctive -- the differences in size computed for a performance measure of any level of aggregation have been adjusted to account for the difference in magnitude calculated for the same measure at the next higher level of aggregation. Thus, the numbers directly considered in the sensitivity analysis actually indicate the residual variability of the performance measures after the differences arising at the next higher level of aggregation have been taken into account. Within this analytic framework, the expanding degrees of detail provided at successively lower levels of aggregation of the various performance measures essentially establish a contextual hierarchy for the interpretation and analysis of the measures.

However, even with this hierarchical structure, the sheer volume of information available for consideration in an analysis of even a single sensitivity issue within the context of a single baseline

scenario is so great that the development of a parsimonious approach for examining this evidence has been imperative. Consequently, detailed consideration of the computed differences in the sizes of performance measures has been restricted to only those differences that are sufficiently large to be indicative of notable disparities in the performance of the prototype. The assessments of sensitivity developed in this study are, therefore, based exclusively on analyses of those performance measures in which exceptional differences have occurred.

For the status measures, the existence of notable differences has been determined by computing chi-square statistics summarizing the observed differences between pairs of analogous frequency distributions. Whenever the values of the statistics are significantly different from zero at the 5 percent level of confidence, the corresponding differences are judged to be exceptional.

For the deviation, mobility, accession/retention, and training measures, it has not been possible to derive such definitive indicators of the existence of notable differences. These other measures neither conform to, nor can they be transformed to permit, the calculation of commonly tabulated indicators of statistical significance. Consequently, based on an intensive review of the differences observed for these measures in a selected sample of pairs of analogous simulations, critical values have been determined for each of these performance measures at each possible level of aggregation. Computed differences in excess of the pertinent critical values are then considered to be exceptional.

By applying the basic approach outlined above, a comprehensive exception report is developed for each of the 36 sensitivity issues in the context of each of the operational situations depicted in the five baseline scenarios. Systematic examination of each of these exception reports then produces a judgment concerning the relative sensitivity of the prototype with regard to each sensitivity issue in each operational situation. This judgment is formed by considering three characteristics of the set of notable differences identified for all of the performance measures in the exception report:

1. The number of notable differences observed for each type of performance measure, and for all performance measures as a group.

2. The pattern produced by the observed notable differences within the hierarchical framework defined by the various levels of aggregation and degrees of detail.

3. The magnitudes of the observed notable differences relative to their respective critical values.

Fortunately, all three characteristics have been highly correlated in virtually all of the exception reports developed in the sensitivity analysis of ISEM-P. The number, the interrelatedness, and the sizes of the notable differences identified in each exception report have exhibited remarkable consistency. Consequently, the judgments embodied in the sensitivity evaluations presented in the following section are essentially independent of any arbitrary determinations of the relative importance of the three characteristics listed above. Virtually identical assessments of the relative sensitivity of the prototype with regard to the various sensitivity issues would be developed for any reasonable specification of the comparative importance of those characteristics.

6.0 RESULTS OF THE ANALYSIS

A summary of the overall results derived by applying the analytic methodology outlined in Section 5.0 to the 36 sensitivity issues defined in Section 4.1, within the context of the five baseline scenarios specified in Section 4.2, is presented in Table 6. For three of the 180 possible combinations of the sensitivity issues and baseline scenarios, application of ISEM-P is impracticable due to the unavailability of sufficient core storage capacity in the present AFHRL computer. For two other combinations, the bases whose representations are stipulated for deletion from the prototype by the sensitivity issues are critical to simulation of the operational situation described by the base closure scenario. Thus, the results of a total of 175 simulations developed using ISEM-P are reported in the table.

For virtually all of the sensitivity issues examined in this study, the outcomes produced by the prototype exhibit remarkable consistency across all five baseline scenarios. For only two issues -- the deletion of Base 7, and the reduction of the length of the simulation from 5 years to 3 years -- does the performance of ISEM-P display appreciably greater sensitivity within the context of one of the baseline scenarios than it reveals in the operational situations described by the other four. Moreover, the observed diversity in performance is entirely reasonable in these two instances.

Deleting the representation of Base 7 from the prototype produces substantial changes in the performance of ISEM-P for the baseline scenario involving reduction of the aircraft utilization rate of all B-52 aircraft, while it evokes only moderate responses with the other four scenarios. However, Base 7 is a SAC operations base in the CONUS to which a B-52 squadron is assigned. Thus, the differential responsiveness of the performance of ISEM-P observed for this modification of its structural assumptions is perfectly logical. Moreover, since this sensitivity issue is the only one focusing on the operation of B-52 aircraft, the absence of analogous response patterns for other sensitivity issues is also sensible.

Similarly, abbreviating the length of the simulation from 5 years to 3 years elicits noticeably greater changes in the prototype's performance for the baseline scenarios involving unchanging mission plans and authorization ceilings over time, than it induces with the remaining four scenarios. The changes in performance occasioned by adjusting the length of the simulation all arise from the manner in which ISEM-P anticipates, and formulates plans with reference to, the end of the simulation. Since these effects can rationally be expected to be more conspicuous when no other stimuli affect the performance of the prototype, the observed response pattern is completely understandable.

Table 6: Overall Results of Sensitivity Analysis

Sensitivity Issue	Baseline Scenario: Constant Authorizations			Base Closure			Reduced Authorization			Reduced Aircraft Utilization			Reduced Retention		
	Airman	Officer	Total	Airman	Officer	Total	Airman	Officer	Total	Airman	Officer	Total	Airman	Officer	Total
Increase standard flying hours	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease standard flying hours	O	O	O	O	◐	O	O	O	O	O	O	O	O	O	O
Increase flight plan coefficient	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease flight plan coefficient	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Increase munition load factor	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease munition load factor	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Increase maintenance manpower factor	O	O	O	◐	O	O	O	O	O	◐	O	O	O	O	O
Decrease maintenance manpower factor	●	O	◐	◐	O	O	●	O	◐	◐	O	O	●	O	◐
Increase work load factor	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease work load factor	O	O	O	-	-	-	O	O	O	O	O	O	O	O	O
Increase base support coefficients	●	●	●	●	●	●	●	◐	●	●	◐	●	●	●	●
Decrease base support coefficients	●	◐	●	●	◐	◐	●	◐	●	●	◐	◐	●	◐	●
Reduce TIC/TOS[a] requirements 6 months	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Reduce TIC/TOS[a] requirements 12 months	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Increase assignment planning horizon	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease assignment planning horizon	O	O	O	-	-	-	O	O	O	O	O	O	O	O	O
Increase retention rates	●	◐	●	●	O	●	●	◐	●	●	◐	●	●	◐	●
Decrease retention rates	●	●	●	●	●	●	●	◐	●	●	●	●	●	◐	●
Double travel times	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Triple travel times	O	O	O	-	-	-	O	O	O	O	O	O	O	O	O

KEY:

- O Low sensitivity
- ◐ Moderate sensitivity
- ● High sensitivity
- \- Analysis infeasible: computer core storage limitations
- -- Analysis infeasible: deleted base critical to base closure scenario

[a]Time-in-CONUS/Time-On-Station
[b]Major Commands

Table 6 (continued)

Sensitivity Issue	Baseline Scenario														
	Constant Authorization			Base Closure			Reduced Authorization			Reduced Aircraft Utilization			Reduced Retention		
	Airman	Officer	Total	Airman	Officer	Total	Airman	Officer	Total	Airman	Officer	Total	Airman	Officer	Total
Change year group distribution	●	◐	●	●	◐	●	●	◐	●	●	◐	●	●	◐	●
Change grade distribution	●	◐	●	●	◐	●	●	◐	●	●	◐	●	●	◐	●
Delete Base 6	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Delete Base 7	◐	◐	◐	◐	◐	◐	◐	◐	◐	●	●	●	◐	◐	◐
Delete Base 12	◐	◐	◐	◐	◐	◐	◐	◐	◐	●	◐	◐	◐	◐	◐
Delete Base 14	○	○	○	○	○	○	○	○	○	◐	○	○	○	○	○
Delete Base 15	○	○	○	○	○	○	○	○	○	◐	○	○	○	○	○
Delete Base 16	◐	○	○	--	--	--	○	◐	○	◐	◐	◐	◐	◐	◐
Delete Base 17	◐	◐	◐	--	--	--	◐	◐	◐	◐	◐	◐	◐	◐	◐
Combine identical CONUS bases	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Consolidate CONUS MAJCOMs[b]	◐	◐	◐	◐	◐	◐	●	◐	●	●	◐	●	◐	◐	◐
Consolidate non-ATC CONUS bases	●	◐	●	●	●	●	●	◐	●	●	●	●	●	◐	●
Minor skill consolidation	◐	●	●	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	●	●
Moderate skill consolidation	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Major skill consolidation	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3-year simulation	●	◐	◐	○	○	○	◐	○	○	◐	○	○	○	○	○

KEY:

○ Low sensitivity
◐ Moderate sensitivity
● High sensitivity
\- Analysis infeasible: computer core storage limitations
-- Analysis infeasible: deleted base critical to base closure scenario

[a]Time-in-CONUS/Time-On-Station
[b]Major Commands

More detailed compilations of the results derived in the sensitivity analysis are presented in Tables 7 through 11. In particular, each of these tables summarizes the outcomes observed for one of the five basic types of performance measures delineated in Section 5.1. Thus, the results obtained for the deviation measures, the mobility measures, the accession/retention measures, the training measures, and the status measures are reported in Table 7, Table 8, Table 9, Table 10, and Table 11, respectively.

The evidence displayed in these tables reveals the same general consistency across baseline scenarios discerned in Table 6. Further, the data also discloses prevalent uniformity in the degree of responsiveness observed, for the same sensitivity issues, across the various types of performance measures. Almost never does a sensitivity issue stimulate predominantly high responses for one type of performance measure, while generating generally low respones for all other types of measures. Only for the issue involving an increase in the maintenance manpower factor is an appreciably greater responsiveness observed for one set of performance measures -- the training measures -- than for the other four sets. In addition, this enhanced sensitivity prevails for only three of the five baseline scenarios.

Even for those sensitivity issues where different degrees of responsiveness are revealed for airmen and for officers, general uniformity exists in the patterns of responses occurring across types of performance measures. Specifically, this condition prevails for the issues involving: decreasing the maintenance manpower factor, increasing or decreasing the base support coefficients, increasing or decreasing retention rates, changing the initial year group distribution, and changing the initial grade distribution.

The tables also disclose general consistency in the response patterns observed for related sensitivity issues. First, considerable symmetry is displayed by the results obtained for those pairs of sensitivity issues that examine both an increase or a decrease in the value of the same parameter, and for which high or moderate overall responsiveness has been revealed. Thus, increasing or decreasing the base support coefficients stimulates corresponding increases or decreases in personnel shortages, surpluses, and movements between bases. Moreover, in both cases, the most notable responses consist of changes in airman shortages. Similarly, increases or decreases in retention rates induce increases or decreases, respectively, in personnel shortages and evoke parallel, but opposite, responses in all of the other types of performance measures.

Table 7: Deviation Measure Results

Sensitivity Issue	Baseline Scenario: Constant Authorizations — Airman	Constant Authorizations — Officer	Base Closure — Airman	Base Closure — Officer	Reduced Authorizations — Airman	Reduced Authorizations — Officer	Reduced Aircraft Utilization — Airman	Reduced Aircraft Utilization — Officer	Reduced Retention — Airman	Reduced Retention — Officer
Increase standard flying hours	O	O	O	O	O	O	O	O	O	O
Decrease standard flying hours	O	O	O	◐	O	O	O	O	O	◐
Increase flight plan coefficient	O	O	O	O	O	O	O	O	O	O
Decrease flight plan coefficient	O	O	O	O	O	O	O	O	O	O
Increase munition load factor	O	O	O	O	O	O	O	O	O	O
Decrease munition load factor	O	O	O	O	O	O	O	O	O	O
Increase maintenance manpower factor	O	O	O	O	O	O	O	O	O	O
Decrease maintenance manpower factor	●	O	●	O	●	O	●	O	●	O
Increase work load factor	O	O	O	O	O	O	O	O	O	O
Decrease work load factor	O	O	-	-	O	O	O	O	O	O
Increase base support coefficients	●	●	●	●	●	◐	●	◐	●	●
Decrease base support coefficients	●	◐	●	◐	●	◐	●	◐	●	◐
Reduce TIC/TOS[a] requirements 6 months	O	O	O	O	O	O	O	O	O	O
Reduce TIC/TOS[a] requirements 12 months	O	O	O	O	O	O	O	O	O	O
Increase assignment planning horizon	O	O	O	O	O	O	O	O	O	O
Decrease assignment planning horizon	O	O	-	-	O	O	O	O	O	O
Increase retention rates	●	◐	●	◐	●	◐	●	◐	●	◐
Decrease retention rates	●	◐	●	◐	●	◐	●	◐	●	◐
Double travel times	O	O	O	O	O	O	O	O	O	O
Triple travel times	O	O	-	-	O	O	O	O	O	O

KEY:

- O Low sensitivity
- ◐ Moderate sensitivity
- ● High sensitivity
- \- Analysis infeasible: computer core storage limitations
- \-- Analysis infeasible: deleted base critical to base closure scenario

[a]Time-in-CONUS/Time-On-Station
[b]Major Commands

Table 7 (continued)

Sensitivity Issue	Baseline Scenario									
	Constant Authorizations		Base Closure		Reduced Authorizations		Reduced Aircraft Utilization		Reduced Retention	
	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer
Change year group distribution	●	◐	●	◐	●	◐	●	◐	●	◐
Change grade distribution	●	◐	◐	◐	●	◐	●	◐	●	◐
Delete Base 6	●	●	●	●	●	◐	●	●	●	●
Delete Base 7	●	●	●	●	●	●	●	●	●	●
Delete Base 12	●	◐	●	◐	◐	◐	●	◐	●	◐
Delete Base 14	O	O	O	O	O	O	◐	O	O	O
Delete Base 15	O	O	O	O	O	O	◐	O	O	O
Delete Base 16	◐	O	--	--	O	O	◐	O	◐	O
Delete Base 17	◐	O	--	--	O	O	◐	O	◐	O
Combine identical CONUS bases	●	◐	●	◐	●	◐	●	◐	●	◐
Consolidate CONUS MAJCOMs[b]	●	●	●	●	●	●	●	●	●	●
Consolidate non-ATC CONUS bases	●	●	●	●	●	●	●	●	●	●
Minor skill consolidation	●	◐	●	◐	●	◐	●	◐	●	◐
Moderate skill consolidation	●	●	●	●	●	●	●	●	●	●
Major skill consolidation	●	●	●	●	●	●	●	●	●	●
3-year simulation	●	◐	◐	O	◐	O	◐	O	◐	O

KEY:

O Low sensitivity
◐ Moderate sensitivity
● High sensitivity
\- Analysis infeasible: computer core storage limitations
-- Analysis infeasible: deleted base critical to base closure scenario

[a] Time-in-CONUS/Time-On-Station
[b] Major Commands

Table 8: Mobility Measure Results

Sensitivity Issue	Baseline Scenario: Constant Authorizations		Base Closure		Reduced Authorizations		Reduced Aircraft Utilization		Reduced Retention	
	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer
Increase standard flying hours	O	O	O	O	O	O	O	◐	O	◐
Decrease standard flying hours	O	O	O	O	O	O	O	O	O	O
Increase flight plan coefficient	O	O	O	O	O	O	O	O	O	O
Decrease flight plan coefficient	O	O	O	O	O	O	O	O	O	O
Increase munition load factor	O	O	O	O	O	O	O	O	O	O
Decrease munition load factor	O	O	O	O	O	O	O	O	O	O
Increase maintenance manpower factor	O	O	O	O	O	O	O	◐	O	O
Decrease maintenance manpower factor	●	O	O	O	●	O	O	O	●	O
Increase work load factor	O	O	O	O	O	O	O	O	O	O
Decrease work load factor	O	O	-	-	O	O	O	O	O	O
Increase base support coefficients	●	●	●	◐	●	◐	●	●	●	●
Decrease base support coefficients	●	●	●	◐	●	◐	●	◐	●	●
Reduce TIC/TOS[a] requirements 6 months	O	O	O	O	O	O	O	O	O	O
Reduce TIC/TOS[a] requirements 12 months	O	O	O	O	O	O	O	O	O	O
Increase assignment planning horizon	O	O	O	O	O	O	O	O	O	O
Decrease assignment planning horizon	O	O	-	-	O	O	O	O	O	O
Increase retention rates	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Decrease retention rates	●	●	●	●	◐	◐	●	●	●	◐
Double travel times	O	O	O	O	O	O	O	O	O	O
Triple travel times	O	O	-	-	O	O	O	O	O	O

KEY:

- O Low sensitivity
- ◐ Moderate sensitivity
- ● High sensitivity
- \- Analysis infeasible: computer core storage limitations
- — Analysis infeasible: deleted base critical to base closure scenario

[a]Time-in-CONUS/Time-On-Station
[b]Major Commands

Table 8 (continued)

Sensitivity Issue	Baseline Scenario									
	Constant Authorizations		Base Closure		Reduced Authorizations		Reduced Aircraft Utilization		Reduced Retention	
	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer
Change year group distribution	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Change grade distribution	●	◐	●	◐	◐	◐	◐	◐	●	◐
Delete Base 6	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Delete Base 7	◐	◐	◐	◐	◐	◐	●	●	◐	◐
Delete Base 12	◐	◐	◐	◐	◐	◐	●	◐	◐	◐
Delete Base 14	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Delete Base 15	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Delete Base 16	◐	◐	--	--	◐	◐	●	●	◐	●
Delete Base 17	●	●	--	--	●	●	●	●	●	●
Combine identical CONUS bases	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐
Consolidate CONUS MAJCOMs[b]	●	◐	●	◐	●	◐	●	◐	●	◐
Consolidate non-ATC CONUS bases	●	◐	◐	●	●	◐	●	●	●	◐
Minor skill consolidation	◐	●	◐	●	◐	●	◐	●	◐	●
Moderate skill consolidation	●	●	●	●	●	●	●	●	●	●
Major skill consolidation	●	●	●	●	●	●	●	●	●	●
3-year simulation	●	O	O	O	O	O	O	◐	O	O

KEY:

O Low sensitivity
◐ Moderate sensitivity
● High sensitivity
\- Analysis infeasible: computer core storage limitations
— Analysis infeasible: deleted base critical to base closure scenario

[a]Time-in-CONUS/Time-On-Station
[b]Major Commands

Table 9: Accession/Retention Measure Results

Sensitivity Issue	Baseline Scenario									
	Constant Authorizations		Base Closure		Reduced Authorizations		Reduced Aircraft Utilization		Reduced Retention	
	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer
Increase standard flying hours	O	O	O	O	O	O	O	O	O	O
Decrease standard flying hours	O	O	O	◐	O	O	O	O	O	O
Increase flight plan coefficient	O	O	O	O	O	O	O	O	O	O
Decrease flight plan coefficient	O	O	O	O	O	O	O	O	O	O
Increase munition load factor	O	O	O	O	O	O	O	O	O	O
Decrease munition load factor	O	O	O	O	O	O	O	O	O	O
Increase maintenance manpower factor	O	O	O	O	O	O	O	O	O	O
Decrease maintenance manpower factor	O	O	O	O	O	O	O	O	O	O
Increase work load factor	O	O	O	O	O	O	O	O	O	O
Decrease work load factor	O	O	-	-	O	O	O	O	O	O
Increase base support coefficients	◐	◐	O	◐	O	◐	O	◐	◐	◐
Decrease base support coefficients	◐	◐	◐	◐	◐	●	◐	◐	◐	◐
Reduce TIC/TOS[a] requirements 6 months	O	O	O	O	O	O	O	O	O	O
Reduce TIC/TOS[a] requirements 12 months	O	O	O	O	O	O	O	O	O	O
Increase assignment planning horizon	O	O	O	O	O	O	O	O	O	O
Decrease assignment planning horizon	O	O	-	-	O	O	O	O	O	O
Increase retention rates	●	●	●	●	●	●	●	●	●	●
Decrease retention rates	●	●	●	●	●	●	●	●	●	◐
Double travel times	O	O	O	O	O	O	O	O	O	O
Triple travel times	O	O	-	-	O	O	O	O	O	O

KEY:

O Low sensitivity
◐ Moderate sensitivity
● High sensitivity
\- Analysis infeasible: computer core storage limitations
-- Analysis infeasible: deleted base critical to base closure scenario

[a] Time-in-CONUS/Time-On-Station
[b] Major Commands

Table 9 (continued)

Sensitivity Issue	Baseline Scenario									
	Constant Authorizations		Base Closure		Reduced Authorizations		Reduced Aircraft Utilization		Reduced Retention	
	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer
Change year group distribution	●	●	●	●	●	●	●	●	●	●
Change grade distribution	●	●	●	●	●	●	●	●	●	●
Delete Base 6	O	O	O	O	O	O	O	O	O	O
Delete Base 7	O	O	O	O	O	O	◐	◐	O	O
Delete Base 12	O	O	O	O	O	O	O	O	O	O
Delete Base 14	O	O	O	O	O	O	O	O	O	O
Delete Base 15	O	O	O	O	O	O	O	O	O	O
Delete Base 16	O	O	--	--	O	O	O	◐	O	O
Delete Base 17	O	O	--	--	O	O	O	O	O	O
Combine identical CONUS bases	O	O	O	O	O	O	O	O	O	O
Consolidate CONUS MAJCOMs[b]	O	O	O	O	O	O	O	O	O	O
Consolidate non-ATC CONUS bases	O	O	O	◐	O	O	●	●	O	O
Minor skill consolidation	◐	●	◐	◐	◐	◐	◐	●	◐	O
Moderate skill consolidation	●	●	●	●	●	●	●	●	●	●
Major skill consolidation	●	●	●	●	●	●	●	●	●	●
3-year simulation	◐	◐	O	O	O	O	O	O	O	O

KEY:

O Low sensitivity
◐ Moderate sensitivity
● High sensitivity
- Analysis infeasible: computer core storage limitations
-- Analysis infeasible: deleted base critical to base closure scenario

[a]Time-in-CONUS/Time-On-Station
[b]Major Commands

Table 10: Training Measure Results

Sensitivity Issue	Baseline Scenario									
	Constant Authorizations		Base Closure		Reduced Authorizations		Reduced Aircraft Utilization		Reduced Retention	
	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer
Increase standard flying hours	O	●	O	◐	O	◐	O	◐	O	◐
Decrease standard flying hours	O	◐	O	◐	O	◐	◐	◐	O	◐
Increase flight plan coefficient	O	O	O	O	O	O	O	O	O	O
Decrease flight plan coefficient	O	O	O	O	O	O	O	O	O	O
Increase munition load factor	O	O	O	O	O	O	O	O	O	O
Decrease munition load factor	O	O	O	O	O	O	O	O	O	O
Increase maintenance manpower factor	O	O	●	O	O	O	●	O	◐	O
Decrease maintenance manpower factor	●	◐	O	O	●	O	O	O	●	O
Increase work load factor	O	O	O	O	O	O	O	O	O	O
Decrease work load factor	O	)	-	-	O	O	O	O	O	O
Increase base support coefficients	O	◐	O	◐	O	◐	O	◐	O	●
Decrease base support coefficients	O	◐	O	◐	O	◐	O	◐	O	◐
Reduce TIC/TOS[a] requirements 6 months	O	O	O	O	O	O	O	O	O	O
Reduce TIC/TOS[a] requirements 12 months	O	O	O	O	O	O	O	O	O	O
Increase assignment planning horizon	O	O	O	O	O	O	O	O	O	O
Decrease assignment planning horizon	O	O	-	-	O	O	O	O	O	O
Increase retention rates	◐	◐	◐	◐	◐	◐	◐	◐	◐	●
Decrease retention rates	O	●	O	●	O	●	O	◐	O	●
Double travel times	O	O	O	O	O	O	O	O	O	O
Triple travel times	O	O	-	-	O	O	O	O	O	O

KEY:

O Low sensitivity
◐ Moderate sensitivity
● High sensitivity
- Analysis infeasible: computer core storage limitations
-- Analysis infeasible: deleted base critical to base closure scenario

[a]Time-In-CONUS/Time-On-Station
[b]Major Commands

Table 10 (continued)

Sensitivity Issue	Baseline Scenario									
	Constant Authorizations		Base Closure		Reduced Authorizations		Reduced Aircraft Utilization		Reduced Retention	
	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer	Airman	Officer
Change year group distribution	●	●	●	●	●	◐	●	◐	●	●
Change grade distribution	●	◐	●	◐	●	◐	●	◐	●	◐
Delete Base 6	O	O	O	O	O	O	O	O	O	O
Delete Base 7	O	◐	O	◐	O	◐	◐	◐	O	◐
Delete Base 12	O	O	◐	O	O	O	◐	O	O	O
Delete Base 14	O	O	O	O	O	O	O	O	O	O
Delete Base 15	O	O	O	O	O	O	O	◐	O	O
Delete Base 16	O	O	--	--	O	◐	◐	◐	O	◐
Delete Base 17	O	O	--	--	O	O	O	O	O	O
Combine identical CONUS bases	O	O	O	O	O	O	O	O	O	O
Consolidate CONUS MAJCOMs[b]	O	O	O	◐	◐	O	◐	◐	O	O
Consolidate non-ATC CONUS bases	O	O	O	◐	O	O	●	●	O	O
Minor skill consolidation	◐	◐	●	●	◐	◐	●	◐	●	●
Moderate skill consolidation	●	●	●	◐	●	●	●	◐	●	●
Major skill consolidation	●	●	●	●	●	●	●	●	●	●
3-year simulation	◐	●	O	●	◐	●	◐	●	O	●

KEY:

O Low sensitivity
◐ Moderate sensitivity
● High sensitivity
- Analysis infeasible: computer core storage limitations
— Analysis infeasible: deleted base critical to base closure scenario

[a]Time-in-CONUS/Time-On-Station
[b]Major Commands

Table 11: Status Measure Results

Sensitivity Issue	Baseline Scenario														
	Constant Authorizations			Base Closure			Reduced Authorizations			Reduced Aircraft Utilization			Reduced Retention		
	Grade	Year Group	Year Group by Grade	Grade	Year Group	Year Group by Grade	Grade	Year Group	Year Group by Grade	Grade	Year Group	Year Group by Grade	Grade	Year Group	Year Group by Grade
Increase standard flying hours	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease standard flying hours	O	O	O	O	O	◐	O	O	O	O	O	O	O	O	O
Increase flight plan coefficient	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease flight plan coefficient	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Increase munition load factor	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease munition load factor	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Increase maintenance manpower factor	O	O	O	O	O	◐	O	O	O	O	O	O	O	O	O
Decrease maintenance manpower factor	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Increase work load factor	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease work load factor	O	O	O	-	-	-	O	O	O	O	O	O	O	O	O
Increase base support coefficients	O	O	O	O	O	O	O	O	O	O	O	◐	O	O	◐
Decrease base support coefficients	O	O	O	O	O	◐	O	O	◐	O	O	◐	O	O	O
Reduce TIC/TOS[a] requirements 6 months	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Reduce TIC/TOS[a] requirements 12 months	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Increase assignment planning horizon	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Decrease assignment planning horizon	O	O	O	-	-	-	O	O	O	O	O	O	O	O	O
Increase retention rates	O	O	●	O	O	●	O	O	●	O	O	●	O	O	●
Decrease retention rates	O	O	O	O	O	◐	O	O	◐	O	O	◐	O	O	◐
Double travel times	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Triple travel times	O	O	O	-	-	-	O	O	O	O	O	O	O	O	O

KEY:

O Low sensitivity
◐ Moderate sensitivity
● High sensitivity
\- Analysis infeasible: computer core storage limitations
-- Analysis infeasible: deleted base critical to base closure scenario

[a]Time-in-CONUS/Time-On-Station
[b]Major Commands

Table 11 (continued).

Sensitivity Issue	Baseline Scenario: Constant Authorizations: Grade	Constant Authorizations: Year Group	Constant Authorizations: Year Group by Grade	Base Closure: Grade	Base Closure: Year Group	Base Closure: Year Group by Grade	Reduced Authorizations: Grade	Reduced Authorizations: Year Group	Reduced Authorizations: Year Group by Grade	Reduced Aircraft Utilization: Grade	Reduced Aircraft Utilization: Year Group	Reduced Aircraft Utilization: Year Group by Grade	Reduced Retention: Grade	Reduced Retention: Year Group	Reduced Retention: Year Group by Grade
Change year group distribution	O	●	●	O	●	●	O	●	●	O	●	●	O	●	●
Change grade distribution	●	◐	●	●	●	●	●	●	●	●	●	●	●	●	●
Delete Base 6	O	O	O	O	O	◐	O	O	O	O	O	O	O	O	O
Delete Base 7	O	O	O	O	O	O	O	O	O	O	O	◐	O	O	O
Delete Base 12	O	O	O	O	O	◐	O	O	O	O	O	O	O	O	O
Delete Base 14	O	O	O	O	O	◐	O	O	O	O	O	O	O	O	O
Delete Base 15	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Delete Base 16	O	O	O	--	--	--	O	O	O	O	O	O	O	O	O
Delete Base 17	O	O	O	--	--	--	O	O	O	O	O	O	O	O	O
Combine identical CONUS bases	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Consolidate CONUS MAJCOMs[b]	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Consolidate non-ATC CONUS bases	O	O	O	O	O	◐	O	O	O	◐	◐	●	O	O	O
Minor skill consolidation	O	O	O	O	O	◐	O	O	O	O	O	◐	O	O	◐
Moderate skill consolidation	O	O	●	O	O	●	O	O	●	O	O	●	O	O	●
Major skill consolidation	O	O	O	O	O	O	O	O	O	O	O	O	O	O	●
3-year simulation	O	O	O	O	O	O	O	O	O	O	O	◐	O	O	O

KEY:

O Low sensitivity
◐ Moderate sensitivity
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[a]Time-in-CONUS/Time-On-Station
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Similarly, within sets of analogous sensitivity issues, broadly comparable patterns of responses uniformly arise. Thus, for those sets of sensitivity issues representing a natural progression of increasingly severe modifications of a single structural assumption, the same fundamental pattern of responses is exhibited for all issues in the set. Most importantly, the strength of the response pattern consistently increases as the severity of the parametric modifications increases. Such sequences of response patterns occur for two distinct sets of sensitivity issues: the three issues involving progressively greater consolidations of skill codes, and the three issues comprising successively more inclusive consolidations of CONUS bases.

Further, where groups of especially comparable sensitivity issues can be distinguished within larger sets of analogous issues, distinctive differences can frequently be discerned among the general response patterns associated with the various groups of highly comparable issues. In particular, within the set of sensitivity issues involving deletion of the representations of certain individual bases, a high degree of consistency pertains in the response patterns derived for three distinguishable groups, while notable disparities prevail among the common response patterns exhibited by the different groups. Thus, a pattern of moderately strong responses is observed for the three issues involving the deletion of representations for CONUS bases, specifically Base 6, Base 7, and Base 12. Because deleting the representation for any of these bases reduces the sizes of certain pools of personnel that serve as sources of replacements for personnel returning from overseas, the predominant feature of this response pattern is the high degree of sensitivity displayed by the deviation measures. In contrast, a different moderately strong response pattern exists for the two issues concerned with the deletion of representations for the PACAF bases: Base 16 and Base 17. In this response pattern, the highest degree of sensitivity is revealed by the mobility measures, because deletion of either PACAF base diminishes the volume of personnel required to rotate periodically through tours of overseas duty. Finally, a considerably weaker pattern of responses, also focusing on the mobility measures, is associated with the two issues involving the deletion of representations for the two USAFE bases: Base 14 and Base 15. This result pertains for two reasons. First, the maximum permissible tour lengths for the USAFE bases are uniformly greater than the maximum tour length for Base 17, and are never less than the maximum tour length for Base 16. In addition, Base 16 contains a larger number and wider variety of missions, and hence accommodates more personnel, than either USAFE base. Consequently, the USAFE bases included in ISEM-P require smaller and less frequent rotation of personnel than is needed by the PACAF bases contained in the prototype.

Comparable disparities in response patterns are observed for four different sets of sensitivity issues addressing alternative modifications of the mission specifications and manning standards embodied in

the prototype. First, a high degree of sensitivity is revealed for the issues concerned with changes in the base support coefficients. A considerably weaker response pattern prevails for the second set of issues, involving changes in the maintenance manpower factor. The third set of issues, examining changes in standard flying hours, exhibit only slight sensitivity. Virtually no responsiveness occurs for the fourth set of issues, pertaining to modifications of the flight plan coefficient, the munition load factor, and the work load factor.

Most significantly, overarching all of the consistency across baseline scenarios and within sets of sensitivity issues discussed above, the results presented in Tables 6 through 11 disclose substantial differences in the relative responsiveness of the performance of ISEM-P to the various changes in parameter values associated with the different sets of issues. Specifically, the results reveal that the performance of the prototype is highly sensitive to:

1. Changes in the initial conditions established in the grade distribution and the year group distribution entered into ISEM-P at the beginning of each simulation.

2. Consolidations of the skill categories identifying the groups of personnel addressed in ISEM-P.

3. Changes in the retention rates controlling the attrition of personnel in ISEM-P.

4. Changes in the base support coefficients determining the manpower requirements for the base support skills in ISEM-P.

Most modest, but still notable, sensitivity is observed for:

1. Changes in the number of bases represented in ISEM-P, achieved either through deletion or consolidation of the representations of individual bases. The differences in the observed sensitivity of the performance of the prototype to these two distinct types of adjustments appears to be primarily attributable to differences in the severity of the adjustments considered in the analysis. The simultaneous deletion of several bases has never been examined, while the consolidation of as many as ten bases has been simulated. Only for such extreme consolidation of bases has high sensitivity been observed.

2. Changes in the maintenance manpower factor determining the manpower requirements for maintenance personnel in ISEM-P.

These sets of sensitivity issues clearly indicate the attributes of the prototype for which it is empirically important to develop accurate representations of AFMPS decision rules and operating conditions. Only with correct characterizations in these critical areas can it reasonably be expected that the outputs derived by ISEM-P might exhibit reasonable correspondence to the actual outcomes that would be observed for the real AFMPS in similar situations.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The sensitivity analysis of ISEM-P conducted in this study reveals remarkable consistency in the responsiveness of the prototype's performance to systematic adjustments in the values of its parameters. Specifically:

1. For each of the 36 sensitivity issues examined in the analysis, considerable uniformity exists in the degree of responsiveness observed for all five types of performance measures employed in the study.

2. The response patterns derived for each of the sensitivity issues exhibit singular uniformity across the five baseline scenarios defining the operational situations for which simulations have been developed throughout the analysis.

3. General consistency prevails in the response patterns observed for related sensitivity issues. Symmetric response patterns occur for pairs of sensitivity issues addressing opposite adjustments in the value of a single parameter; and increasingly strong response patterns arise for increasingly severe parametric modifications.

4. For groups of particularly comparable sensitivity issues within larger sets of analogous issues, uniformity exists in the response patterns developed for the especially comparable issues, while distinctive differences occur among the general response patterns associated with the various homologous groups.

Precisely because of this general consistency exhibited by the analytic results among performance measures, across baseline scenarios, and within sets of related sensitivity issues, it is possible to discern dramatic differences in the relative responsiveness of the performance of the prototype for the various sets of related sensitivity issues. This evidence indicates that the performance of ISEM-P is highly sensitive to:

1. Changes in the initial year group distribution.

2. Changes in the initial grade distribution.

3. Consolidations of skill categories.

4. Changes in personnel retention rates.

5. Changes in base support coefficients.

In addition, moderate sensitivity is revealed for:

1. Deletion of representations for certain bases.

2. Modest consolidations of base representations.

3. Changes in the maintenance manpower factor.

For all other sets of sensitivity issues examined in the analysis, the performance of ISEM-P exhibits low sensitivity.

It is important to realize that a determination of high, or moderate, responsiveness of the prototype's performance for any sensitivity issue does not indicate that the values initially specified in ISEM-P for the parameters associated with that issue are incorrect. Rather, such a determination merely indicates that formulation of an accurate representation of the corresponding AFMPS decision rules and operating conditions is crucial to the derivation of outputs that conform acceptably to the actual outcomes that would occur in the real AFMPS in analogous situations.

From this perspective, the analysis strongly suggests that it would be beneficial to validate the accuracy of the representations contained in ISEM-P for the AFMPS decision rules and operating conditions associated with those sensitivity issues for which the performance of ISEM-P has been determined to display high responsiveness. More specifically, it is recommended that research efforts should be devoted to identifying the precise decision rules employed by the AFMPS, and the precise conditions under which the AFMPS operates, when addressing the sets of sensitivity issues listed previously, for which the performance of the prototype has exhibited high, or moderate, responsiveness in this sensitivity analysis. Then, the corresponding representations of those decision rules and operating conditions currently embodied in ISEM-P should be meticulously reviewed, and revised or replaced as necessary, to assure their satisfactory conformance to the actual rules and conditions prevailing in the real AFMPS. Achieving these research objectives will provide the dual benefits of improving the quality of the outputs produced by ISEM-P as simulations of actual AFMPS performance and of increasing confidence in the potential usefulness of the ISEM concept as an analytic foundation for AFMPS planning and policy formulation.